SCIENTIFIC AMERICAN

No. SUPPLEMENT 341

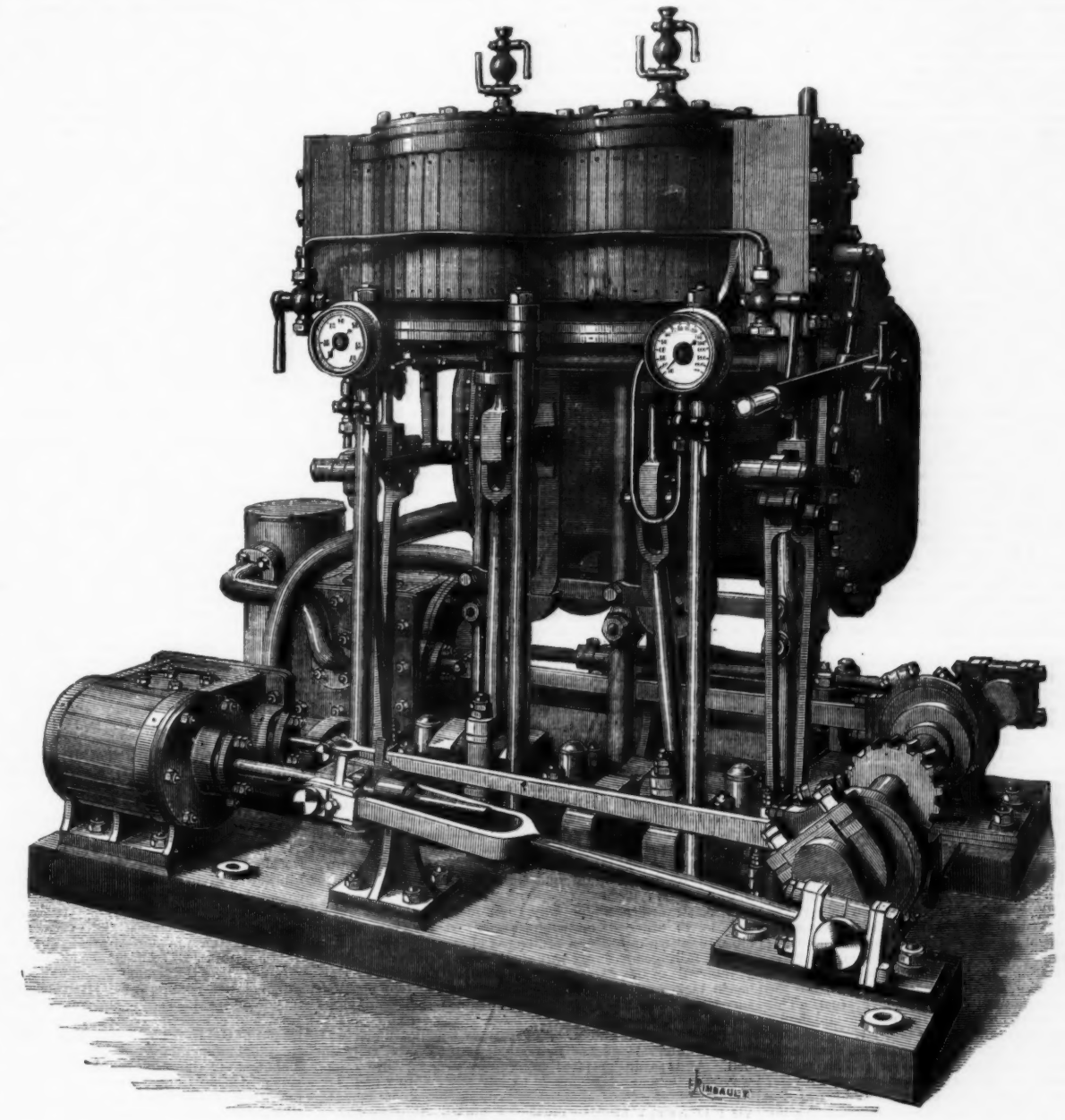
Scientific American Supplement. Vol. XIV., No. 341. Scientific American. established 1845.

NEW YORK, JULY 15, 1882.

Scientific American Supplement, $5 a year. Scientific American and Supplement, $7 a year.

COMPOUND ENGINE FOR YACHTS.

AT the recent Naval and Submarine Exhibition London, a very neatly finished compound surface condensing engine for a steam yacht was exhibited by Messrs. I. Copley & Co., of Middlesbrough; of this engine we now give a perspective view. The engine is of the intermediate receiver type, and has high and low pressure cylinders, seven inches and eleven inches in diameter respectively, the stroke in both cases being eight inches. The cylinders are carried by wrought-iron standards as shown; the three back columns which carry the cross-head guides are stiffened by connections to the condenser. The latter is of ordinary construction, and its arrangement will be readily understood from our engraving.



COMPOUND STEAM ENGINE FOR YACHTS.

The engines illustrated are intended to run at 400 revolutions per minute, and the bearing surfaces are very large throughout. To reduce the speed of the air and circulating pumps these are driven from cranks at the ends of a cross shaft shown, this shaft having at its center a wormwheel gearing into a worm on the crankshaft. The ratio of this worm gear is one to four, so that the air and circulating pumps only make one double stroke for every four revolutions of the engines. Both the air and circulating pumps are of solid brass, and they are both fitted with slide valves in place of the ordinary lifting valves, the arrangement being exactly like that of an ordinary steam cylinder, except that the exhaust port is the suction port. Both the air and circulating pump are double acting.

The whole arrangement of the engines is very neat and accessible, while the proportions are substantial, and the general finish of the engines exhibited was excellent.—*Engineering.*

ON THE ECONOMY OF COMPOUND ENGINES.*

By W. PARKER.

DURING the last few years I have watched with great interest the steam pressure in merchant ships increased from 60 lb. per square inch to 70 lb. and then to 80 lb., and from inquiries among my friends I have learned that an appreciable gain in economy of fuel resulted therefrom. At present very few engines are being made to work at a lower pressure than 80 lb., while 90 lb. appears to be the more common pressure in use; still I am almost inclined to doubt if sufficient economy of fuel can be realized by going above 80 lb. or 90 lb. per square inch with the two-cylinder type of engine now in use. Having lately been investigating this subject I think that a short description of the results obtained may not be uninteresting to this meeting.

The reason why, in general, higher steam pressures are conducive to economy is that they render possible a greater measure of expansion; as the most part of the work is done without any further expenditure of heat than originally supplied in the steam before expansion, but there are limits beyond which expansion of steam is not beneficial, and it is to these limits that I wish to draw attention.

If we conceive a perfect gas originally at a high pressure and at any temperature to expand during work, the work will be done at the expense of the heat of the gas, and its temperature will fall by an amount proportional to the work done during expansion, unless an equivalent amount of heat be added as expansion takes place. If this heat be added, the relation of the pressure and volume during expansion is such that their product at any time is constant, but if no heat is added during expansion the pressure falls much below that which it would have been according to this law.

In the case of steam we have a much more difficult matter, as any reduction of temperature below that due to the pressure causes immediate condensation. However, when the law by which the pressures and temperatures of steam vary is known, and also the total amount of heat necessary to produce steam of any given pressure, we are able to calculate the variations of pressure and volume of steam, if we know what heat is given to or taken from it, and also what work is done by it during expansion.

For example, if we take a given volume of dry saturated steam at a pressure of 140 lb. per square inch (absolute), and let it expand doing work, we shall require to add heat to it at every step of the expansion in order to prevent liquefaction taking place, and although heat is added its temperature falls.

If now we were to allow the steam to expand without adding heat to it or taking heat from it, but doing work during expansion, we should have partial condensation taking place. If now we could by any possibility allow steam to expand thus, say by using a perfectly non-conducting cylinder, we should get the maximum of work possible out of the steam, but, as I have stated, condensation must then take place. In practice, however, we are compelled to use cylinders of metal, the inner surfaces of which must be polished, and of course polished metal is a very superior conductor of heat; the inner surface of the cylinder must therefore always be tending to become of the same temperature as the steam immediately in contact with it. When it is colder than the steam it rapidly condenses part of it, absorbing its latent heat until its increased temperature is equal to that of the steam, while if the temperature of the steam is less than

* Read at the twenty-third session of the Institution of Naval Architects.

that of the cylinder, the surplus heat of the cylinder will by evaporating any condensed moisture on its surface rapidly lose heat until equilibrium of temperature again results.

This is the process which must take place in a cylinder every stroke if the piston moved sufficiently slow, but even with a fast moving engine the temperature of the inner surface of the cylinder will always be somewhere between that of the steam at entry and exit. When therefore the steam first enters any cylinder, its temperature is reduced by contact with the cylinder, and a certain amount is condensed; the effect of this is to warm the walls of the cylinder and the piston; as expansion takes place the temperature of the steam falls until it becomes lower than that of the cylinder, and then the hotter cylinder re-evaporates part of the condensed steam; when the exhaust opens, a further reduction of pressure takes place as it escapes into either a receiver or a condenser, and thus the re-evaporation becomes complete.

On fresh steam re-entering, as much of this is condensed as is required to raise the temperature of the cylinder to that of the entering steam; the effect of this whole operation is to admit a larger quantity of steam from the boiler than ought to be required to fill the cylinder. It will thus be seen that in an actual engine the expanding steam must be having heat abstracted from it during a part of the forward stroke by the cylinder walls, in addition to that converted into work, while an amount of heat is added to it during the latter part of the same stroke, and during the whole of the return stroke in re-evaporating the condensed steam. The portion returned to the steam during the forward stroke helps to do some useful work by increasing the forward pressure, but the portion added to the steam during exhaust (really by increasing the back pressure) not only is directly wasted but is actually creating resistance. It is therefore evident that the greater the amount of expansion the greater will be the range of temperature, and the greater the range of temperature the greater will also be the amount of liquefaction and re-evaporation taking place, so that a point is reached at which with further expansion the greater variation of temperature causes greater losses of heat than is compensated for by the additional work done. Now, provided we can expand the steam continuously, allowing the pressure to fall only as work is done, it is immaterial whether the expansion is effected in one or in more cylinders.

In the compound engine as in general use, however, this expansion is somewhat interrupted, the steam after it is cut off in the high-pressure cylinder expands until it fills this cylinder, and at the end of the stroke it expands further, without doing work, into the receiver; this represents a loss compared with what would have been realized by continuous expansion, and in addition, the steam having to pass through tortuous passages in obtaining its exit from the high-pressure cylinder into the receiver and from the receiver into the low-pressure cylinder, a loss of direct pressure is experienced, the forward pressure in the low-pressure cylinder when this is fully open to the receiver being generally two or more pounds less than the back pressure in the high.

Although a very considerable loss may thus be shown to take place in the best designed compound engine, yet the fact has been proved beyond question that the compound engine even with this loss is more economical by far than the simple engine, and the reason it is so is because by expanding the steam in two cylinders the range of temperature becomes divided into two, and in neither cylinder does such a great amount of condensation take place. For instance, with steam of 60 lb. per square inch above the atmosphere expanding to say 10 lb. absolute, or 5 lb. below the atmosphere, a single cylinder will be exposed to a range of temperature from 307 to 194 degrees during the forward stroke, and then to 100 degrees during the return stroke, while in the compound engine the ranges will be from 307 to about 215 degrees in the high-pressure cylinder, and from 215 to 100 degrees in the low.

In an ordinary compound engine, as we increase the pressure, so also do we at the same time increase the range of temperature, and further, unless the high-pressure cylinder is made unduly large, so that a long range of expansion takes place in it, a large amount of unbalanced expansion takes place from the high-pressure cylinder to the receiver. With increased condensation a limit must be reached in which further expansion in the two-cylinder engine will produce more losses from these causes than the gain from the additional expansion, exactly in the same way as with the simple engine a limit was soon reached beyond which additional expansion was injurious. In other words, if pressures and expansions are carried beyond this limit we shall have to again compound our compound engines.

What this limit is must be ascertained by direct experiments, and I am sure that the engineering world are looking forward with intense interest to the results which will be obtained by the steamship Aberdeen on the forthcoming voyage as an experimental fact toward settling this point.

Unfortunately, with marine engines it is almost impossible to determine their absolute efficiency; the only facts as to their performance which can be accurately noted are the indicated horse powers and the consumption of fuel. This gives a measure of the efficiency of the engine and boiler combined, but in order to eliminate the boiler we would require to know, in addition to the amount of water evaporated and also the amount of condensation water and its rise of temperature (this would enable us to know how much water was in the steam when it enters the engine, and also at any subsequent part of the stroke), but these quantities are not measurable in engines of large power such as are fitted to the ordinary steamers employed in the mercantile marine.

Although it is impossible from the indicator diagrams to ascertain how much condensation takes place, yet in carefully analyzing them, the re-evaporation during the latter part of the stroke can easily be seen, but that which takes place when the cylinder is open to the condenser cannot, of course, be ascertained in this way. If the clearance spaces of each cylinder be accurately measured and the actual volumes of the steam at each pressure be set off in a diagram, as shown in the figures, it will be found, I believe, in every case, that after the cut-off the curve formed will rise higher than the adiabatic curve through the cut-off point, showing that re-evaporation does take place, while in all cases the low-pressure diagram will fall below the adiabatic curve drawn through the fullest point of the high-pressure diagram, further showing that some portion of the steam must pass through this cylinder as water, never showing on the indicator diagram at all, being re-evaporated during the return stroke directly into the condenser.

I have constructed diagrams showing the relative volumes and pressures of steam in the case of the steamship Aberdeen, taking indicator diagrams kindly given to me by Mr. Prior, from the performance of that vessel at the power at which she will work at sea, and also from diagrams taken from two two-cylinder compound engines, one of them working at the same boiler pressure, viz., 125 lb. per square inch.

In the latter case a considerable departure is visible in the high-pressure diagram from the adiabatic curve (or curve of perfect engine), while very considerable condensation is shown in the low pressure cylinder more than that in the high pressure, and considering the rapid rate of evaporation in the high-pressure cylinder toward the end of the stroke, I believe that a very considerable amount of the steam must even thus be left condensed.

In the two first diagrams of the steamship Aberdeen very little evaporation is shown, and this is what we should have expected from the small range of temperature in them. Again, in the case of the engines of the steamship Northern being ordinary compound engines working at a pressure of 88 lb. per square inch, although the compression parts of the diagram clearly show that the high-pressure piston is leaky, yet the pressure in this case toward the end of the stroke rises above the adiabatic curve while very considerable condensation has taken place in the low-pressure cylinder, and had the piston been tight these would of course have been more marked.

I think we may assume that the nearer the expansion curve in practice approaches that due to the perfect engine, the better will be the performance of the engine, and from these diagrams I have formed the opinion that the limit of beneficial expansion with the two-cylinder compound engine is about reached at a pressure of between 80 lb. and 100 lb. per square inch, and that in order to obtain better results with steam above that pressure we must compound our present compound engines.

I may mention that within the last few weeks there has been a steamer completed to work at a pressure of 150 lb. per square inch with triple expansion engines very similar to those fitted in the Aberdeen, and in my opinion this description of engine marks one of the most important of recent advances in the history of marine engineering, affording a means of using steam at higher pressures than have hitherto been used with economy.

SOUND SIGNALING.

A LECTURE on "Sound Signals" was lately delivered at the Naval Exhibition, London, by Mr. Price Edwards, of the Trinity House.

The lecturer, after referring to the use of visible signals—such as semaphores and colored lights, which are familiar objects on our railways—went on to say that of late years it has been found necessary to introduce signals which can be heard, because the use of visible signals necessitates a clear atmosphere, in the absence of which the signals cannot be seen. In the case of a ship involved in a fog, the captain trusts to his compass and to his reckoning, and he must proceed very slowly, and use the very greatest precautions against accident; and when he is near land he must take the greatest care, for he cannot see the lights which would otherwise guide him on his way and enable him to steer clear of dangers. Consequently sound signals have been introduced to take the place of lights in such a case. It is also often necessary for vessels approaching one another to intimate which course they are about to take, in order that they may avoid collision. Twenty years ago the dangers of our coasts were very imperfectly indicated in foggy weather, and the only means that vessels had of communicating with one another by sound consisted of an indiscriminate and unintelligible whistling, and a shouting through speaking trumpets.

The Americans, who have a large seaboard, and who also have large inland waters, found it necessary to use sound signals, because a thick fog on their coasts came very often indeed, and stopped their traffic. They were too enterprising to allow their traffic to remain stopped, and they were the first to adopt sound signals. At first they placed them on their lighthouses, for use when the lights could not be seen. Then their vessels which used to navigate their huge rivers—such as the Hudson, the Mississippi, the Ohio, and other inland waters—were obliged to have sound signals on board, to enable them to tell neighboring vessels which side they should pass. England, generally somewhat less advanced than America, ultimately, about twenty years ago, took up the matter. We have made very marked advances as regards sound signals, beyond anything that was thought to be attainable in earlier days. Nowadays the law steps in and requires merchant ships to use sound signals under certain conditions. For merchant ships the international regulations for preventing collisions at sea prescribe, as a compulsory requirement, that in fog, mist, or falling snow, whether by day or night, the signals described as follows shall be used:

(*a*) A steamship under way shall make with her steam whistle, or other steam sound signal, at intervals of not more than two minutes, a prolonged blast.

(*b*) A sailing ship under way shall make with her fog horn, at intervals of not more than two minutes, when on the starboard tack, one blast; when on the port tack, two blasts in succession; and when with the wind abaft the beam, three blasts in succession.

(*c*) A steamship and a sailing ship when not under way shall, at intervals of not more than two minutes, ring the bell. And, as an optional proceeding, a steamship under way may indicate her course to any other ship which she has in sight by the following signals on her steam whistle, viz.: One short blast to mean, "I am directing my course to starboard;" two short blasts to mean, "I am directing my course to port;" three short blasts to mean, "I am going full speed astern." A gun fired at intervals of about a minute is one of the authorized signals of distress at sea. In the Royal Navy the above regulations are also in force; but, in addition, Captain Colomb's system of sound signaling is employed in fog for the purpose of communication between her Majesty's ships. By far the most important development of sound signals is in connection with the lighthouse and coastmarking service. The most powerful lights are unavailing at night if enshrouded with fogs, and, by day, buoys, beacons, and other marks and signs of the sea are rendered useless. The necessity of sound signals to do duty at such times has brought about the development of the system of coast fog signals, which have proved to be of the greatest service to navigators.

We have learned a great deal from the Americans on this subject. Among the instruments used for the purpose of sound signaling, first, there are bells, varying in weight from 3 cwt. to 2¼ tons. The bells themselves are fixed, and they are made to ring by the swinging of the clapper or hammer. These bells give very feeble sounds at all times. At a distance they are not of great use to sailors; the sound is not intense enough. But still there is one way in which a bell continues to be very usefully employed, and that is on the top of a floating buoy. Such a bell has four clappers, which strike the bell at four different points as the buoy is oscillated by the waves. Another kind of sound producer is the gong. Gongs are used on board lightships, and although the sound they produce is but small, it is, perhaps, generally sufficient for the purpose, because lightships are generally moored in deep water, and vessels can approach them pretty closely. More powerful gongs are now coming into use.

Next there are guns and explosive signals. Guns are used to indicate that vessels want assistance, and on board her Majesty's ships they are used for signaling in foggy weather. They have also been employed occasionally as signals on headlands. The old long 18-pounder gun was formerly used, but it was afterward found that shorter guns produced a better effect. Experiments have shown that small grain powder will cause the loudest explosion, the reason of this being that it burns with greater rapidity than powder of larger grain. The fact that the loudness of an explosion depends upon the rapidity of the combustion is shown by the detonation of gun-cotton and other explosives of the same nature. An 80-ton or 100-ton fired with 300 lb. or 400 lb. of pebble powder, does not make so distressing a noise as the explosion of 1 lb. of gun-cotton.

THE GAS GUN.

There is a very ingenious invention called the gas gun, which has been patented by Mr. J. R. Wigham, of Dublin. The advantages claimed for this gun are that where a supply of gas is invariable the apparatus is very easily applied, and that the gun can be loaded and fired at a considerable distance from the point of explosion. The gun consists merely of a tube of about 18 in. bore and 12 ft. long, placed at the point where the signal is required to be made, and connected with a gas main or gas holder by iron piping. The gun is loaded with an explosive mixture of gas and atmospheric air by the simple turning of a cock, and is fired by a light applied by percussion or otherwise at the shore end of the tube. The explosion takes place at the mouth of the gun almost immediately. Mr. Wigham says that a gas gun may be fixed at the water's edge, or on a rock at sea, at half a mile from the loading and firing station.

Experiments were made some years ago at the Royal Arsenal for the purpose of observing the sound produced by the explosion of gun-cotton. The explosion of this substance takes place so instantaneously that an exceedingly sudden and sharp blow is given to the surrounding air, whereby a sound wave of great initial intensity is produced. To discharge small charges of gun-cotton suspended from string, and with the necessary electric connections, entailed a deal of trouble, and was inconvenient where it was required to be done after a long interval; but it was clearly shown that the explosion of gun-cotton gave a very good sound, and a plan was devised by which a rocket was made to carry up a charge of gun-cotton into the air to a height of 600 ft., and there to explode it.

THE SOUND ROCKET.

There is in use now a sound rocket charged with what is known as cotton powder, which is a slight modification of gun-cotton, and which goes up into the air and makes a great noise. A quarter of a pound is sent up as a charge, and it explodes in the air free from all obstructions, and makes a most effective sound. It is much cheaper than firing a gun. The gun used to be fired every ten minutes. The rocket goes up as long as its composition burns. When it has nearly finished burning it sets fire to a piece of cotton connected with the fuse. The fuse communicates with the detonator, and the explosion communicates itself to the cotton powder charge. This sort of rocket is now used at five stations on the British coast and at Heligoland. For the purpose of distinction some attempts have recently been made to get two distinct explosions from one rocket by sending up two charges together. This idea it is hoped will soon be made practically successful. The cotton powder that is now made may be handled and stored with as much safety as gunpowder, and it is less easily exploded by contact with flame; but it has not yet been shown that other explosive compounds, such as dynamite, lithofracteur, blasting gelatine, or any other nitro-glycerine mixture, can be made practically serviceable.

THE CARTRIDGE SIGNAL.

There is one other signal which may be mentioned. The Cotton Powder Company are exhibiting in the present Exhibition a kind of signal which may be fired more easily, expeditiously, and effectively than a gun, thereby obviating the need to load every minute—an important consideration with a vessel in distress. This consists of a small charge of tonite—cotton powder—made up into a sort of cartridge. When required to be used one of the cartridges is dropped into a socket; the seaman stands aside and pulls a lanyard attached to a friction tube. By this means a small quantity of powder at the base of the tube is ignited. This ignites a fuse, and causes the charge to shoot up into the air to a height of 600 ft. The cotton powder then explodes, and at the same moment a group of stars are thrown into the air. This form of signal makes the same sound as a cannon, and acts also as a rocket. Many vessels are using this appliance, and the Board of Trade have agreed to accept it in substitution for the gun as a signal in case of shipwreck. This plan can also be adopted for use in boats. Boats when leaving a wrecked ship are often without any means of making themselves seen; but these signals would enable them to do so, and they are so small that a supply of them can be carried under the seat of a boat. This signal can be made readily distinguishable at great distances.

WHISTLE SIGNALS.

The lecturer next dealt with signaling by means of whistles. Whistles are sounded either by steam or by air. Steam whistles are simple enough in their arrangement, and require only a boiler for generating steam and a mechanical arrangement for opening a valve to allow the passage of the steam to the whistle. In the case of air whistles it is necessary to have some arrangement to compress the air, and also some means of regulating the admission of air to the whistle. The sound of a whistle is caused by the vibration of the air contained within the bell, or dome, or column, the vibration being set up by the impact of a column of steam or air at a high pressure. It is probable that the metal of the bell or column of air is likewise set in vibration, and gives the timbre or quality to the tone that is emitted by the whistle. Difference of pitch is obtained by altering the distance between the steam orifice and the lip

of the bell. When these are brought close to each other—say within half an inch—the sound is very shrill. If you increase the distance the sound becomes much deeper. A recent adaptation of the whistle as a fog signal has been made in an automatic signal buoy. The sound is produced by the movement of the buoy on the top of the water. A large tube descends for a considerable distance into the water. This tube is open at the end, so that there is a piston of water in the tube continually, and this compresses the air by the motion of the waves, and forces it up through the whistle; and thus the whistle is continually sounded. Whistles are supposed to be the best medium for making signals by sound on board steamships. The regulations already quoted specify the whistle for steamers. It is necessary that precaution should be taken to insure that whistles give effective sounds. In many cases, when first sounded, one hears only a rush of water, which has resulted from the condensation of steam; so that the whistle is ineffective if the signal is required to be made in a great hurry. A novel form of whistle, consisting of an organ pipe fitted to a steam pipe, has recently been introduced. It is said that it does not get choked like ordinary whistles, and that the sound emitted is loud and resonant. This instrument is patented by Messrs. Hannen & Buchanan, of Glasgow. Messrs. Smith Brothers, of Hyson Works, Nottingham, exhibit in the present exhibition a new form of whistle, in which two sounds can be made with one instrument. This is a great desideratum, and may afford the means of making what is so necessary in these days, namely, distinctive and effective signals to indicate the compass course of a vessel.

HORNS AND SIRENS.

The next class of instruments to which reference should be made is horns. These originally came from America, and the characteristic of them is that they are sounded by reeds instead of being sounded in the form of a whistle. Some forms of fog horns are exhibited by Mr. Nathaniel Holmes, of Holmes's Marine Life Protection Association. These horns are put into a stirrup, and worked up and down. The seamen are supposed to be able to work them easily, if they can stand upright; but that may want a little support to enable them to do so. These horns are made with reeds, and are said to be very effective for certain purposes. Mr. Pilley, of Birmingham, exhibits a reed horn, the characteristics of which are that it will give either a continuous blast, or a short one as may be desired. The continuous blast is managed by putting an external chamber round the cylinder and piston, which compresses the air, and keeping the chamber full of compressed air, so that the air is supposed to go through uniformly, the current being kept so long as the sound is required. It is not certain, however, that this is an advantage, for it is often necessary that these things should stop, and not go on continually.

There has been brought to this country from America an apparatus known as Barker's marine safety signal. This apparatus has many merits. One is simplicity of working. Another of its merits is that every signal is sounded automatically when once set; and a third advantage is that with the horn attached it gives a very good sound. Compressed air is employed, at a pressure of 6 lb. to the square inch, and the sounding principle is a reed for the horn. The inventor says that it can be equally well connected with the steamer's own whistle. The main object of the inventor appears to be to bring into use a short code of compass signals, by means of which vessels can indicate to one another their respective courses. This signal system contains a combination of eight long and short sounds.

Another instrument for use in fog is the siren. This also came from America. This can be sounded either with steam or with compressed air, and the principle upon which the sound is made is that the steam or air passes first through a fixed flat disk which has twelve radial slits, and is fitted into the throat of a long trumpet. Behind the fixed disk there is fitted a revolving disk, with exactly similar slits. A pressure of air or steam directed against the fixed disk goes through the second or revolving disk when the slits of the two disks coincide at certain periods, according to the quickness of the rotation. If the pressure is very high, and the rotation is very rapid, the succession of puffs passing through is very rapid indeed, and a very intense sound is produced. The vibrations are not taken up by the metal trumpet, which is of cast iron, and the sound issues from the mouth in a continuous beam of great intensity. Since 1874 no fewer than twenty-two sirens have been placed round our coast, and sixteen have been put on board lightships. These are of the greatest service to passing navigation. At Howth Bailey, a gas engine is employed as a motor, for compressing air for the siren in operation there. This arrangement is there due to Mr. Wigham, of Dublin. Messrs. Stevenson, of Edinburgh, have suggested that a Perkins engine should be used as a motor for siren signals, and perhaps it will be so used one day. The adoption of the siren as a sound signal in foggy weather may be regarded as an important advance in the development of these instrumental fog signals. Sundry modifications have been recently added to them, among others a mechanical movement, by which Professor Holmes has succeeded in rendering the rotation of the siren cylinder automatic, with perfect control of the speed and consequent pitch. Mr. Holmes has also introduced a double siren, by which two notes can be got out of the same instrument, but this is not generally used at present. With the increasing use of sound signals, there is an increasing necessity for making them differ from one another, and it is very useful to have inventors brought together, that they may see the various inventions which have been developed and brought out for the purpose of signaling by sound. It may be, that if instruments are devised sufficiently accurate to make sound signals which shall be trustworthy and useful, ultimately the law will be altered to suit those instruments; but inventors must not expect that a change in the law will be made in favor of their own particular instruments.

HARBORS AND ESTUARIES ON SANDY COASTS.

AT a recent meeting of the Institution of Civil Engineers, London, the paper read was on "Harbors and Estuaries on Sandy Coasts," by Mr. L. F. Vernon-Harcourt, M.A., M. Inst. C. E.

This communication contained a concise history of the progressive alterations of the harbors along the south coast of the North Sea, between Calais and the mouth of the Scheldt, namely, Calais, Gravelines, Dunkirk, Nieuport, Ostend, and Blankenberghe. These harbors owed their origin to the existence on their sites of an outlet channel communicating with a creek or small lagoon, and maintained by the flux and reflux of the tide, and the drainage waters of the adjacent district. The first artificial works consisted of short timber jetties on each side of the channel, to mark and protect its outlet. By degrees the inland tide-covered areas were reclaimed, and the entrance channel being deprived of the tidal scour, gradually deteriorated. Attempts were then made to improve the entrance by prolonging the parallel jetties into deeper water. These jetties had been made in every case solid at the base, and with open timberwork above, so that, while preventing the sand on the beach from washing into the channel, as little obstacle as possible might be presented to the littoral current. Owing, however, to the sand-bearing character of the tidal current along the coast, every advance of the jetties had been followed by a corresponding advance of the foreshore. The maintenance and deepening of the entrance channel was at the same time promoted by retaining the inland and tidal waters at high water by sluice gates, which, being opened at low water, released a large volume of water for scouring away the deposit of sand. Sluicing basins, admitting a large quantity of tidal water, had also been formed at various times in most of these harbors, to increase the efficiency of the scouring current. A large new sluicing basin was in course of construction on the low foreshore, near the entrance of Calais Harbor, for deepening the entrance channel. The jetties at Dunkirk had been extended out to a distance of about 2,500 feet from the shore, without realizing the object of attaining deep water, as the foreshore had advanced so much as to overlap the western jetty at low-water spring tides. The large sluicing basin at Dunkirk was being replaced by a series of docks and basins, which, however, had been designed so as to allow of the same amount of water being available for sluicing. As a bar tended to form just outside the jetty channel, dredging by sand pumps was being resorted to for deepening this part of the entrance. This method of improvement was commenced in 1876; and the quantity of material removed last year amounted to about 314,000 cubic yards. The deepening thus effected had produced a considerable increase in the trade of the port, more especially by admitting vessels of larger tonnage. The approach channel to Ostend, which was maintained in former times by the tidal scour from extensive marsh lands, had, since their reclamation, been improved by parallel jetties and well-placed sluicing basins; and dredging was now being resorted to for improving the depth over the bar beyond the jetties.

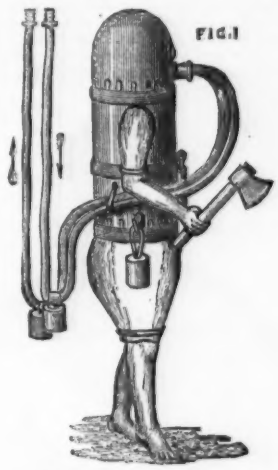
A brief comparison was next drawn between the jetty harbors described and other harbors, and it was shown that the continental practice of prolonging parallel jetties and sluicing had not been in most cases adopted in the United Kingdom, but that the system of inclosing a large tidal area by solid piers converging so as to form a narrow entrance had been preferred, as, for instance, at Aberdeen, Dublin, Sunderland, and Lowestoft. It was pointed out that the extension of parallel jetties had proved of no avail, and it was suggested that converging piers aided by sluicing would probably afford the best prospect of maintenance in an unfavorable situation like Dunkirk, while dredging would serve to maintain the depth outside the entrance where the scouring efficiency was lost. Boulogne Harbor was cited as an instance of the conversion of a jetty harbor into a large closed harbor, which, owing to the projection of its entrance into deep water, gave a good prospect of successful maintenance. Madras Harbor furnished an example of a closed harbor constructed on a sandy coast, where the advance of the foreshore had been dreaded; but, owing to the depth of water—45 feet—into which the piers were being carried, and the removal by the north-east monsoon of a portion of the sand accumulated against the south breakwater during the south-west monsoon, it seemed probable that the foreshore would not approach near the entrance for a long period. The experience gained at Ymuiden, Port Said, Madras, Karachi, and other harbors, tended to show that a considerable littoral drift was not an insuperable obstacle to the effective maintenance of a harbor with solid piers on a sandy beach. For, provided that the entrance was carried into deep water, the rate of advance of the foreshore continually decreased, and might even reach a position of equilibrium; the sand introduced through the entrance was small, and the projecting piers tended to produce a scour in front. Estuaries were next considered, and the works at the mouths of the Adour, of the Seine, and of the Maas, were discussed. It was shown that the jetty system adopted for the Adour had been only partially successful, and that the influx of the tide had been checked owing to the jetties at the mouth having been placed too close together. The restriction of the tidal Seine within embankments, from La Mailleraye to Berville, though producing an improved channel up to Rouen, had caused such an unexpectedly rapid silting up of the estuary as, within thirty-three years, to have reduced the tidal capacity of the Seine by 272,000,000 cubic yards, and endangered the approaches to Havre. The shifting channel below the termination of the banks had not been improved by the works, and its maintenance would be imperiled unless the banks were prolonged. It was suggested that the embankment works should be carried to the mouth, in such a manner as to reduce the diminished tidal capacity as little as possible, and so as to direct the main channel toward Havre. The works at the new mouth of the Maas were then referred to. They consisted of a cut across Hoek-van Holland, with jetties at right angles to the shore, leading the channel into deep water, and providing the shortest possible channel from Rotterdam to the sea, along the Scheur branch of the Maas. The jetties, composed of fascine work, were raised only to half-tide level, and slightly diverging formed a sort of prolongation of the river banks into the sea. The southern jetty, 2,515 yards long, had been made to project beyond the northern jetty, which was 2,200 yards long, in order to prevent an eddy produced by the flood current, which tended to raise a bar. The depth of 23 feet at high water, which was anticipated at the mouth, had not been attained. The deficiency in depth had been attributed by some persons to a too rapid widening out near the mouth. The author, however, ascribed it to the narrowness of the new cut compared with the width of the river above, and of the channel between the jetties; to the natural progression of the foreshore near the jetties, produced by the littoral currents and the action of the waves; and to the material scoured from the cut in the process of construction having remained near the jetties.

In conclusion, the author discussed the general question of training rivers through sandy estuaries, and pointed out that where such works were commenced they had gradually to be extended, as in the case of the Fen rivers. The Mersey, above Liverpool, was cited as an instance where training works might imperil the outlet channel. The proposals for training the Scheldt through its estuary were referred to, and any great reduction of its tidal capacity deprecated. Lastly, a comparison was made between the methods of improving the outlets of the Maas and the Tyne.

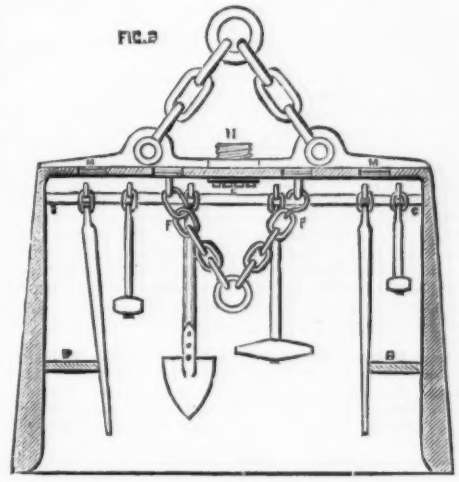
APPLIANCES FOR WORKING UNDER WATER, OR IN IRRESPIRABLE GASES.*

By W. A. GORMAN.

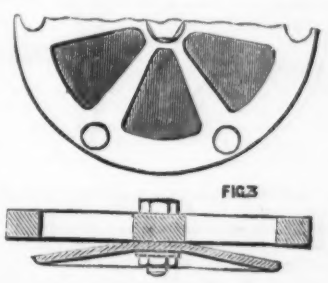
THE first account of the use of the diving bell in Europe is that of Tasnier, who relates that in 1538, at Toledo in Spain, he saw two Greeks, in the presence of Charles V., let themselves down under water in a large inverted kettle without being wet. Lord Bacon—A.D. 1600—describes the primitive method adopted in his time. In 1632 Richard Norwood took out a patent for a special means to dive into the sea. Borelli, in 1669, constructed a copper vessel 2 ft. in diameter, with glass fixed before the face of the diver;



this he termed a "vesica." It was worn as a helmet, and securely attached to a dress of goatskin. Within the "vesica" were pipes, by means of which a circulation of air was contrived. About the year 1700 Dr. Edmund Halley devoted much time to subaqueous experiments, and in 1716 he read a paper before the Royal Society, entitled "The Art of Living under Water." He turned his attention to the diving bell. In 1721 he described to the Royal Society a method by which the diver could leave the bell. He used pipes, 40 ft. in length, made with spiral brass wire inside; one end was fixed in the bell, and the other to a cock which opened into the diver's cap. This was made of



lead, weighing 56 lb., and he also wore a girdle of the same weight, and clogs of lead weighing 12 lb. each. About 1716 John Lethbridge invented an air reservoir, made of wainscot, perfectly round, and 6 ft. long, 2 ft. 6 in. in diameter at the head, and 1 ft. 6 in. at the foot. He compressed air into this with a pair of bellows, and then lowered it with himself under water, where he remained 34 minutes. Numerous inventors followed in his track. Smeaton, in 1779, first employed the diving bell for civil engineering operations in repairing the bridge at Hexham, Northumberland. The apparatus was an oblong wooden box, 4 ft high, 2 ft. wide, and 3 ft. 6 in. long. It was supplied with air

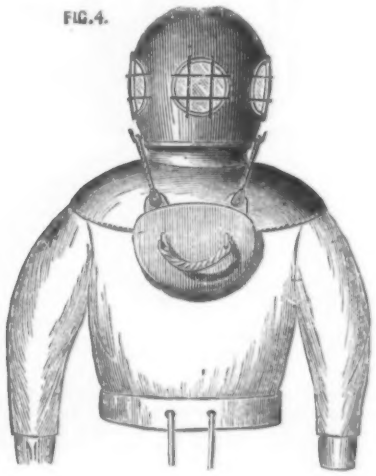


by a pump fixed on surface. A diving dress was invented in 1798 by Kleingert, of Breslau, which consisted of strong tin-plate armor, Fig 1, in the form of a cylinder incasing the diver's head and body with a leather jacket and strong leather drawers. These were made waterproof, and joined by brass hoops around the metal armor, so that the diver was relieved from the pressure of the water except on the legs and arms. He inhaled the air from the surface through one pipe, and the vitiated air was carried to the surface by another. A diver could not with this apparatus descend to

* Abstract of a paper lately read before the Institution of Mechanical Engineers, and reported in the *Engineer*.

greater depths than 20 ft. About the same date Messrs. John and William Braithwaite constructed a diving apparatus, with which they carried out several successful operations. Rennie, while occupied on the works of Ramsgate Harbor, 1813, made considerable improvements in the diving bell; he designed and constructed a diving bell of cast iron, Fig. 2, 6 ft. high, 4 ft. 6 in. wide, and 6 ft. long, with one side a little heavier than the other, so that it should not float quite level, and thus more readily allow the vitiated air to escape. At the top of the bell six thick bull's eyes of glass, M M, were fixed to admit light. In the center of the top was a circular hole, N, in which a brass lining was firmly fixed. To the under side of this was attached the air valve, E, on a brass grating of the form shown in Fig. 3. The valve itself was simply a disk of strong leather. A nozzle was fixed to the top of the bell above the valve, and to this was screwed a watertight leather hose 2½ in. diameter, connected to the air pump, which was constantly worked by a sufficient number of men. Inside the top of the bell

FIG. 4.



were strong lugs, to which were attached chains, F F, Fig. 2, for suspending stones or other material. The bell was fitted with seats, B B, and a rail, C, for hanging the various tools used by the men; it was slung by stout chains from a double-purchase crab fixed on a truck, which could travel along the gantry; the total weight was five tons. Rennie used this diving bell with great success in the numerous harbor and other works with which he was associated.

Open Diving Dress.—In 1828 or 1829 the late Mr. Augustus Siebe was employed in the construction of a diving dress, afterward known as the open-helmet diving dress. The helmet was made of copper with a screw lens in front, Fig. 3, and a metal elbow riveted on the back of the headpiece, to connect the air pipe with the pumps, the headpiece and breastplate being in one. To the breastplate was attached a canvas jacket, which, with the aid of two lead weights, kept the helmet fixed upon the shoulders. Boots with lead soles, weighing 12 lb. each, were worn, and also a waterproof dress fastened round the neck, over which were placed the helmet and jacket. The air escaped into the water from underneath the outer canvas jacket, and the water reached within a few inches of the diver's mouth, so that he had to work in a vertical position. The air pumps had three cylinders, 3 in. diameter, 9 in. stroke. Even at the present day many of the coast divers use this form of dress.

Close Diving Dress.—About 1839 Mr. Siebe introduced the close helmet, Fig. 5, fitted with inlet and outlet valves, I and O, and with a segmental neck screw, to remove the head-piece by one-eighth of a turn. The waterproof dress was fastened to the metal collar by screws and brass bands.

Modern Apparatus.—This apparatus, as illustrated in Figs.

FIG. 5

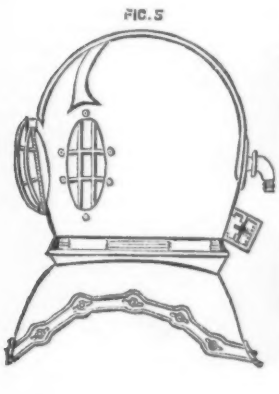


FIG. 6

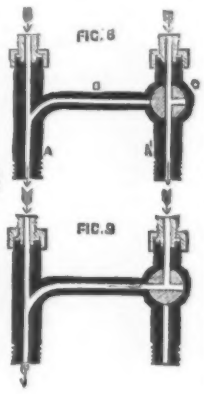
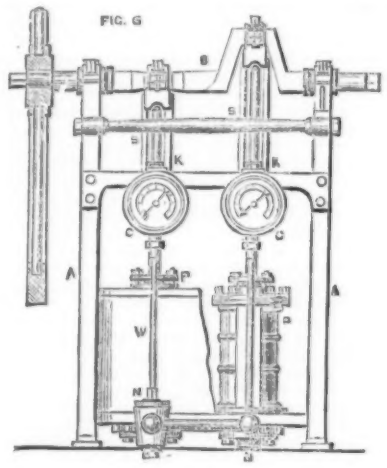


FIG. 9

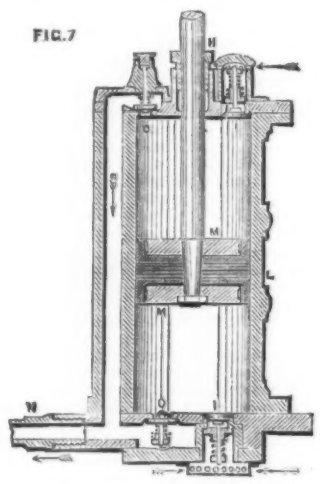
6 and 7, is a very perfect one, combining a high degree of safety with comfort for the diver. The air pump, Fig. 6, is capable of compressing air to a pressure of 240 lb. per square inch, and consists of two vertical double-action gun-metal cylinders, PP, securely fixed to a bed-plate of gun-metal, which is bolted on the base of two side standards, A A, forming an iron framing to carry the crank shaft, B. Each piston, Fig. 7, is constructed of two inverted cups of leather, L L, with leather packing placed between, and the whole is secured by two cast iron piston plates, M M, fitted to the piston-rod inside the leather cups, and pressed together by a nut. Grooves are formed in the periphery of the piston plates to contain expanding springs, which, pressing against the inner side of the leather cups, keep them in close contact with the cylinders, and thus maintain the piston in a perfectly air-tight condition. Each cylinder cover has an oil tap for lubrication. The piston-rods pass through glands, H, packed with turned leather washers, and are extended so as to work in guides, K K, Fig. 6. Double connecting slings, S S, with gun-metal bearings, connect the piston-rods to the crank pins. Inlet and outlet valves, I and O, Fig. 7, are fixed in the covers of each cylinder, and also in the base plate. Spindle valves are used, faced with leather, and with gun-metal seatings, to which the valve is kept by a spiral spring. The top and bottom outlet valves are connected by passages cast on the cylinders, and leading to the air delivery nozzle, N. The cylinders are surrounded by a copper cooling cistern, W, Fig. 6. Pressure gauges, G G, show the depth and pressure at which the diver is working, and are also used for testing the air pipes. Each gauge is marked off to represent the pressure in pounds per square inch, at given depths of water from 20 ft., where the pressure is 8·68 lb., to 204 ft. and a pressure of 88·54 lb., which is the greatest depth a diver has been known to descend—140 ft. is given as the practical limit of diving, the pressure being 60·76 lb. The air-distributing arrangement, by which the air can be transmitted to one or two divers as occasion may require, is as follows: The two outlet nozzles, A A, Fig. 8, are connected by a cross branch pipe, B, and a three-way cock, C, is fixed at the junction of

FIG. 6



the pipe, B, with the nozzle, A. The position of this cock, when supplying air from both cylinders to one diver, is shown in Fig. 9, while Fig. 8 shows the position when two divers are to be supplied, each being in connection with one cylinder. If at any time the pump is supplying one diver, and it is necessary to send down the second diver to his assistance, it is only necessary to turn the lever of the cock, C, round to the position marked "two divers," and work the pump faster. Two divers can work from it to a depth of 90 ft., or one diver to a much greater depth. The improved helmet, Figs. 10 and 11, is made of tinned copper, and consists of two parts, the breastplate and the headpiece. The breastplate is so constructed that the diver has free use of his arms, and can reach over the headpiece. It has a segmental neck ring, R, so that the headpiece can be removed by one-eighth of a turn, and has a brass band, S, at the bottom, with twelve screw studs, to which are fitted four brass plates fastened by wing-nuts, thus forming the junction with the waterproof dress. A is an air passage for conducting the air supply over each lens, so as to prevent the diver's breath from condensing upon the glass. B is a nozzle to which the air pipe is connected, and inside which is placed an inlet valve; in case of accident to the air pipe the air pressure inside would close this valve, and thus prevent the water from entering the helmet. D is the front lens, which can be unscrewed, so that the diver can converse without being undressed, and E is the side lens. O is the outlet valve for the escape of vitiated air into the water. G is a stud for securing the weights, and H a regulating tap, by means of which the diver can regulate his

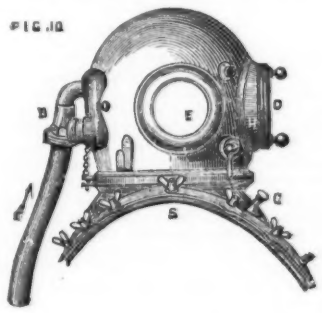
FIG. 7



supply of air without giving a signal. Fig. 12 shows a section of the outlet valve, which is placed at the side of the helmet, and within reach of the diver; it is a metal cone valve over which is screwed a metal cap, A, with small holes drilled in it to allow the air to escape into the water. The valve spindle is kept in position by a hard-drawn copper wire spring. There is a second brass cap, B, screwed on the first one, and having a small opening. In this the diver can insert his finger and press down the valve spindle so as to confine the air, and thus inflate his dress and rise to the surface. The valve has a small metal chamber, C, carried up a short distance, so that the opening into the helmet is 4 in. above the valve. The waterproof dress is made of strong tanned twill, with an India-rubber lining between the thicknesses of the material. It has mineralized India-rubber collar and cuffs. The boots have lead soles weighing 14 lb. each. At the front and back are lead weights 40 lb. each. An air-pipe with spiral wire embedded in it and joints fitted to connect up to any desired lengths; a knife, in water-tight case, a leather belt and pipe-holder, and a double suit of flannels, complete the equipment. For deep water the men wear a body guard to keep off the pressure. The author then described some of his experience in working.

Appliances for Working in Irrespirable Gases.—The Fleuss apparatus represents a great improvement in this direction. It is self-contained and entirely independent of any communication with the outer atmosphere, thus enabling the wearer to breathe with safety in the most noxious gases. The principle of the apparatus is that the wearer breathes the same air over and over again, the carbonic acid being absorbed from it after each expiration, and at the same time the requisite amount of oxygen restored; thus rendering it pure and fit to be again inhaled into the lungs. The apparatus, Fig. 13, consists of a strong copper cylinder, D, 6½ in. diameter, and 12 in. long, with domed ends, and capable of containing 4 cubic feet of oxygen, at 16 atmospheres pressure, this being sufficient for four hours' respiration. Above the cylinder, D, is attached a square metal box, B, 12 in. by 12 in. by 4 in.; this contains the carbonic acid filter, which is a box of vulcanite divided into four compartments by vertical diaphragms, in such a manner that the exhaled breath of the wearer is made to pass twice up and down through the vessel, before it is in a position to be again inhaled. This box is fitted with small cubes of India-rubber sponge, saturated with a thick pasty solution of caustic soda. The exhaled air, being finely divided as it passes through the interstices of the sponge, and coming in

FIG. 10

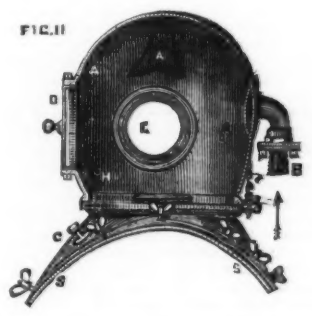


contact with a very extended surface of caustic alkali, becomes thoroughly cleansed of all the objectionable products of respiration. As shown in Fig. 14, a flat bag, G, of vulcanized India-rubber, 12 in. by 15 in., is strapped on in front of the wearer; into this the exhaled air passes from the filter, by means of a tube of India-rubber. The bag is also in communication with the oxygen chamber, D, and the supply of oxygen to the bag, G, is regulated by a jamb screw valve, T, Fig. 13, under the control of the wearer. The mask, A, Fig. 15, is made to fit airtight to the face of the wearer, and is held in place by straps buckled at the back of the head. A band of rubber is made to cover the ears, and the eyes are protected by glass, when it is necessary to go into smoke or gases that would hurt them. The mask is provided with a pair of flexible tubes, E, with valves, the one for exhaling being in communication with the filter, and the one for inhaling being connected to the air bag. The slightest effort of inspiration brings the revivified air freely to the lungs of the wearer. The whole apparatus weighs 26 lb., and can be adjusted in two minutes. The author considers this apparatus particularly adapted for the use of coal mines, or when men have to deal with noxious gases. Mr. Fleuss has remained in the densest smoke, as also in a glass chamber charged with carbonic acid, for a considerable time. In conclusion, the author alluded to the use of electric light for submarine purposes, as the only light which can really be of use to the diver. The telephone, he said, had not been fully tested in practice, the divers preferring their ordinary signal line, or communicating by a slate.

Before the discussion commenced, Mr. Gorman exhibited a complete diving helmet and other apparatus, and said that since the paper was written Mr. Fleuss' apparatus not long since saved ten lives in the Killingworth Colliery, and had also been used at the opening out of the Maudlin seam in the Seaham Colliery.

Mr. Fleuss showed the action of the apparatus. He said the dress was put on, and the tube put in the miner's mouth, but the mask was simply placed on the forehead, and he

FIG. 11



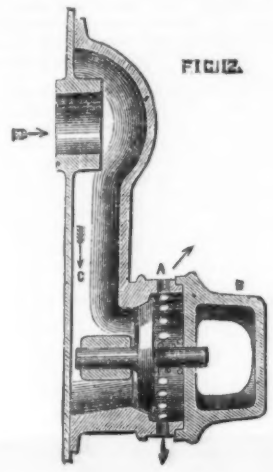
went into the pit in that position. The mask and breathing apparatus could be adjusted in a moment in case he came suddenly into foul gases. By putting his hand behind and turning the tap, he could at any time get more air; and this had to be done every ten minutes. This air was pure oxygen admitted to the bag, G, which was 300 or 400 cubic inches from the reservoir, D. He could make the man if he chose breathe only the proper mixture of oxygen and air by first inflating the bag with breath. The arrangement explained was perfectly safe, because as long as any oxygen was there it would be supplied to the bag, and whenever the man found the volume was not sufficient—irrespective of purity—he could put his hand down and admit more. The carbonic acid remained, of course, in the filter, forming carbonate of soda, and the volume of gas thus abstracted was made up by the oxygen. He had made an improved filter, since the paper was written, in which, instead of India-rubber sponge, he was simply using tow mixed with caustic soda, and made in sticks. It made an efficient filter, and when the soda was completely carbonized, the whole

could be thrown away. The sponge cost a sovereign, but a halfpennyworth of tow was sufficient for the same purpose.

Mr. Charles Cochrane bore testimony to the admirable and prompt way in which work could be carried out in mines, even when it was necessary to telegraph to London for apparatus.

Mr. Druit Halpin suggested that the glass shield in front which had to be taken off when necessary to speak to the

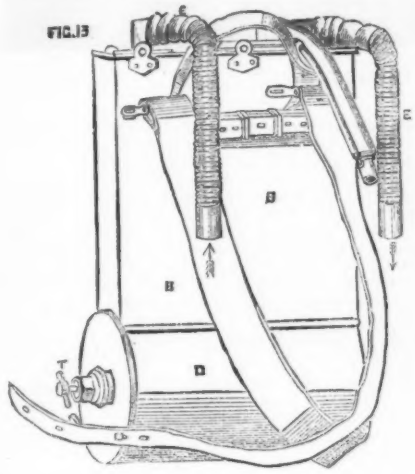
FIG. 12.



man, and then put on again, might be improved. If the buttons for unscrewing were made like common winch-handles, and then milled, they would give a chance of doing what was wanted without dropping the shield overboard.

Mr. Charles Hawksley said that he had occasion to repair a pump which failed in a well of small diameter. In that confined situation one of the parts of the pump gave way, and the only means of getting at it to do the necessary repairs was by means of divers. A diver was sent down by the author's firm, and although the well was crowded with

FIG. 13



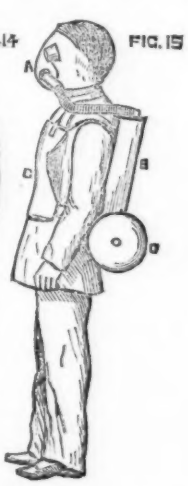
pump trees and their means of support, he descended to a depth of 130 ft., and in that depth of water he successfully replaced the broken part; so that the pump was able to be set to work again with comparatively little delay.

Referring to some remarks made by Mr. Cowper, Mr. Halpin said it was easy to get rid of any difficulty connected with fish getting in the way of the electric light, by injecting a small quantity of paraffin into the water round the lamp, which at once drove the fish away.

Mr. Fleuss said that in working in pits it was utterly

FIG. 14

FIG. 15



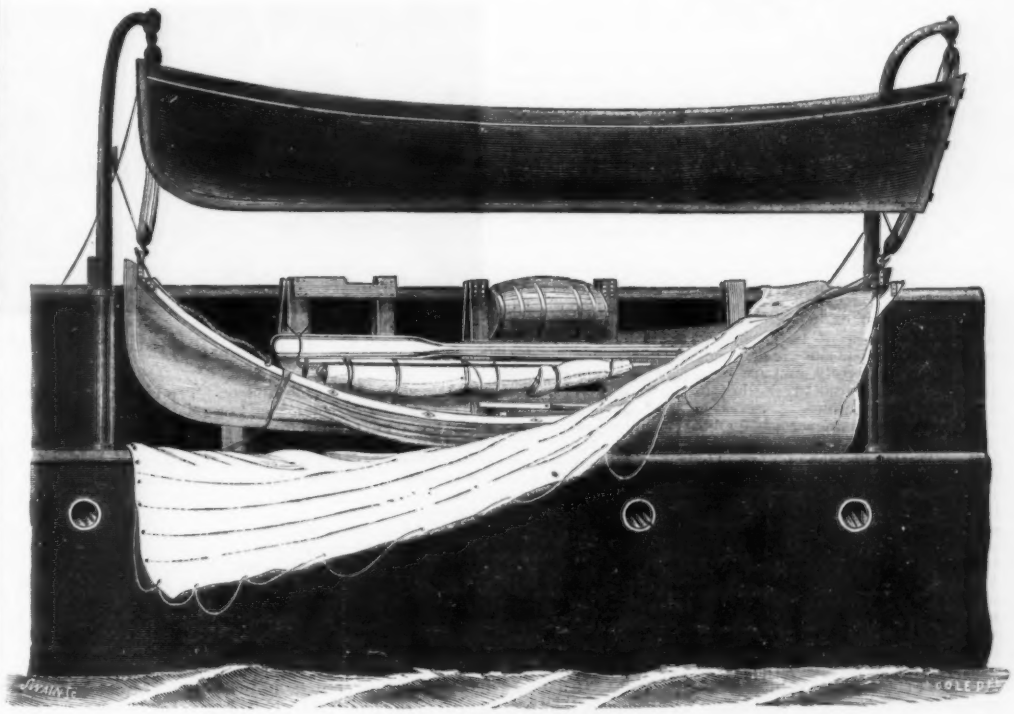
impossible, although the apparatus was complete for breathing, to work without a light; and where the gases were so dense that the men could not breathe them, it was necessary to have some special kind of light. He exhibited a lamp which he had designed for the purpose, and which he had frequently carried when working in the Maudlin seam at Seaham. The vessel could be kept charged for any length of time, by using common precautions in shutting off the valve. It could be easily seen at any time whether the valve was properly shut, by putting a film of moisture across the hole, when in an instant it would be seen if gas was leaking even to the smallest extent by bubbles appearing on the film. To insure a sufficient supply of the oxygen gas, it might be carried in an iron store cylinder containing 30 cubic feet, under a pressure of 600 lb. to the square inch. Apart from that plan it was very easy to make oxygen gas. All the theaters made it for their lime lights, and he had left a complete set of gear for making it at the Seaham Colliery, after working for five months. It comprised a mercury bottle converted into a retort, with a pipe attached. There were two purifying vessels containing simply water—changed as often as you liked—to wash the chlorine out of the gas. There should be two or three bags to hold the gas as it was made, and in twenty minutes you could get off enough gas to charge one breathing machine, and in a few minutes longer enough to charge several more. He had used the machine all the time he was there, keeping two or three store bottles in reserve, in case of the pump breaking down, which it did once or twice from the extra strain put on it, and the firing of the leathers. They were working day and night with six lamps and six breathing machines, and these were constantly being taken up, refilled, and taken down again.

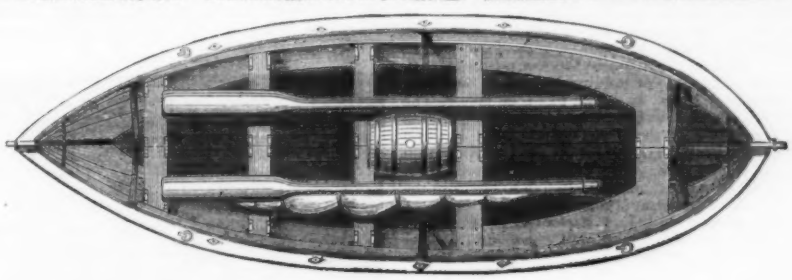
Lieut. Dean Pitt gave a description of the diving operations which were carried out at the wreck of the Doterel. In reply to a question, he said that the temperature inside the dress entirely depended upon how they were working. If they worked hard, the temperature rose very high, and they sometimes had to rest a few minutes to get cool. But what they suffered from chiefly was the intense cold to their hands. With regard to the light, the water was very clear indeed, and they could very fairly distinguish what a thing was at a distance of 7 ft. or 8 ft., though they could not see the parts distinctly.

into deep water. They also urged the Royal Engineer officers to dive. In the Navy the officers could also learn diving, if they chose to do so; and they had just heard an instance of the value of that system, because Lieutenant Pitt's examination of the wreck was most valuable to the Admiralty when he was summoned home to give evidence at the court-martial. Again, the value of the sponge imported into this country each year amounted to £90,000, and that mostly recovered by helmet divers. Lately the pearl fisheries in the Torres Straits had also become very extensive. A schooner arrived a short time ago with a very valuable cargo, which had been fished up in six weeks, and which realized £8,000. There were now a number of vessels fitted out for that purpose. Altogether, therefore, the apparatus was being developed in other directions. He had been carrying out a number of experiments with the telephone, and had made it very perfect. At present, if two divers under water placed their helmets together, they could hear one another converse. But with the new instrument, if two divers placed their helmets together they could hear at the surface what the men were talking about. He hoped to exhibit this on a future occasion.

THE BERTHON COLLAPSIBLE BOAT.

THIS boat was exhibited and described by its inventor, the Rev. E. L. Berthon, M.A., in a lecture delivered during the recent Naval and Submarine Exhibition, London. The discourse was entitled, "On the Supply of an Abundance of Lifeboats to the Royal Navy and Mercantile Marine." Mr. Berthon, in introducing the subject, remarked that his audience would agree that the subject which was intended to be illustrated most prominently at the present Naval Exhibition was the means of saving life at sea. He believed





THE BERTHON COLLAPSIBLE BOAT.

Mr. Gorman, in reply to the discussion, thanked Mr. Halpin for the suggestion he had made, which would be of great assistance in screwing up the glass when the hand was cold. Mr. Cochrane had referred to his efforts in sending off some men for him about ten days back. They had been sent off in two hours after receiving the telegram, and in twenty-four hours they had completed the work allotted to them, and prevented a serious disaster. They had done the same thing on several occasions for Mr. Marten and others. It was true that the men preferred to work without artificial light. They became actually like blind men; the sense of feeling became very acute, and, working from day to day, as they did, they became wonderfully quick at the work they had to perform. In the case of the wreck of the Caledonian, the men took the engines to pieces under water, and sent them up, also the boilers, and that was done in total darkness. With regard to the air-lock diving bell, Mr. Stoney's great bell, used in 1871, was somewhat different in construction from the one exhibited, being of cast iron in sections bolted together, whereas the bell to which he had referred was made of wrought iron, the upper chamber of $\frac{3}{8}$ in. and the lower of $\frac{1}{2}$ in. plate. But he was indebted to Mr. Stoney for very valuable hints, having been in correspondence with him during the time he was constructing the bell for the Barbados. With reference to the uses of the diving apparatus at the present time, the Admiralty now attached so much importance to the subject that they had established two classes for training divers, one at Portsmouth and the other at Devonport, and they had annually from eighty to ninety divers trained for the service. The Royal Engineers also had classes formed at Chatham; the men were trained in the Medway, and they also went down and dived off Sheerness, where they got

that every thinking person would be convinced that something more must be done than has at present been accomplished. In the last few years ocean navigation has gone on extending with rapid strides.

Our ships are getting larger and larger, and the number of passengers which the ships carry is increasing in still greater proportion; but until recently it has been impossible to supply those ships with adequate life-saving apparatus in the shape of boats. Rafts, life-buoys, floating mattresses, and inflated necklaces, are very excellent articles, for they will

sustain shipwrecked persons in the water, so that they may have a chance of being picked up; but they only serve as temporary refuges, and they may merely lead to a lingering death unless boats are at hand to take the people out of the water. What is needed is sufficient boat accommodation to save all hands on board. Two typical shipwrecks which occurred not many years ago, namely, those of the Northfleet and the Cospatrick, illustrate the great need which exists for more boat accommodation than is now provided.

The Northfleet was an American ship of about 1,000 tons, and her crew and passengers all told amounted to 496 per-

sons; but she had boat accommodation for not much more than one quarter of that number. The Cospatrick was of about the same tonnage, and she also had about 500 persons on board. At the Board of Trade inquiries which followed the loss of these ships the owners were held perfectly harmless and exonerated from all blame, because it was discovered that the boat accommodation was up to the requirements of the act of parliament, that requirement being that a 1,000 ton vessel should carry boats capable of holding 140 persons. On board the Northfleet the boats were so crowded when the order was given to lower them that the davits were actually bent down with the weight of the people. Nearly all the people on board the Northfleet perished through an insufficiency of boats. The Cospatrick took fire in smooth water and fine weather, about 180 miles from the coast of Africa. The crew—44 in number—did all they could to extinguish the flames. After the fire had burst through the deck, and had even caught the rigging, the chief officer said to the commander, Captain Elsey, "Shall I put out the boats?" "No," replied the captain, "put out the fire." Some very ill-natured comments were made by the press upon this utterance of the captain, but perhaps the captain did quite right.

There were on board more than 440 men, women, and children, and if the crew had been taken from their fire duty to lower the boats those boats would have been swamped by the people jumping into them. Only one boat left the ship, and that contained thirty-one persons. This boat was picked up, after thirteen days, with only three survivors. If there had been boats enough to hold all the people on board the captain's order would have been very different. If it was known that the boat accommodation on board a vessel was sufficient, discipline could be maintained, and the passengers could be got into the boats without confusion. So long as the law remains as it is with regard to the proportion of boat accommodation to be carried by passenger ships, so long will the present awful deficiency of boats and the terrible risk of life continue.

Emigrants are leaving our shores at the rate of about 280,000 a year, and at one time the number reached 1,000 persons every day. The ships of all our large steam companies carry admirable boats so far as the boats themselves are concerned, but they are not sufficient in number to save a quarter of the people on board. Even small boats will live in a rough sea if they are properly managed. In the wreck of the London, a dingy 14 feet long, under clever management, was the means of saving fourteen people. One of the Berthon boats being exhibited in the Hall had been carried by the Spartan, one of the Union Steamship Company's vessels, and had done admirable work in Algoa Bay. She had been used to keep up communication with the shore, and had stood up to her canvas and taken the sea in a most remarkable way, while other boats were almost swamped.

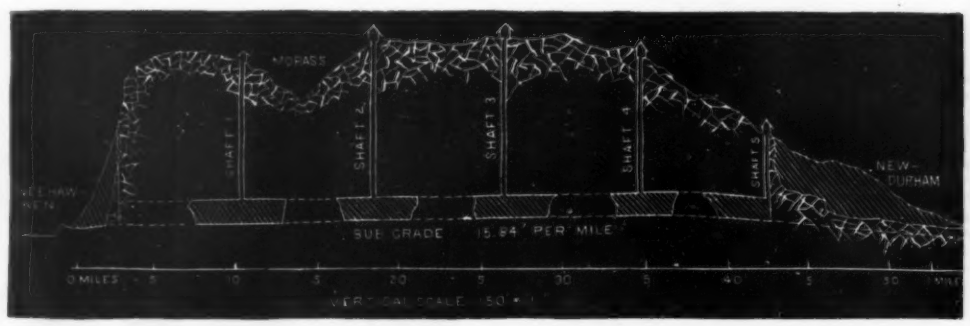
The Berthon boat, when folded up, occupies about one-fifth or one-sixth of the space occupied by an ordinary wooden boat. The ribs are of wood, and run longitudinally instead of transversely, and are jointed at the stem and the stern, and the space between the ribs is filled up with canvas instead of planking. A second layer of canvas is placed inside, and thus there is formed a boat within a boat. This arrangement also divides the whole of the body of the boat into compartments, the number of which corresponds with the number of the spaces between the adjacent timbers. The timbers stand out in radiating planes when the boat is open, and lie down in vertical planes when the boat is shut. The shut boat occupies only one-sixth of the open width. As soon as the weight is brought on to the spans the boat opens of its own accord. A Berthon boat will stand an amount of knocking about which would be sufficient to destroy a boat of ordinary construction. The gunwales and all the timbers are formed of a highly elastic and very expensive kind of wood. This material is cut into strips and steamed, and then bent in moulds and riveted with copper rivets; and thus a complete bow is formed. The boats are provided with good keels and good bilge keels, and if they strike the ground they escape without damage, for although they are made of canvas, they are not flimsy. A sharp stone may cut a hole in the canvas, but even in this case the boat does not go down, for the shell is divided into eight compartments, and the entry of water is restricted to the wounded compartment. A large boat, capable of holding forty men, had been cast off and lowered at sea by two men in 1 min. 20 sec. The lecturer had no doubt that with a proper crew the operation could be performed in half that time. One of the Berthon boats was put on board the Teuton on the very morning that she sailed on her last voyage. The Teuton was wrecked off the Southern coast of Africa, about forty-five miles from the Cape, and a statement has gone abroad that the Berthon boat failed on that occasion; but this statement is altogether erroneous, for the fact is that no attempt was made to open the boat, and much less to lower it. It went down bodily with the ship.

The lecturer was led to the invention of this boat many years ago by an accident which occurred in connection with the loss of the Orion in the year 1849. Within a fortnigh after its construction he submitted a model to the Admiralty superintendent at Portsmouth, and it was reported upon in most favorable manner. One of those boats, capable of holding 350 men, was supplied to the unfortunate Great Eastern, but no ship in the world would require a boat of that size now. The shipowning interest had been opposed to the introduction of the folding boat, not because they were afraid of the expense which would be entailed by the adoption of it, but because in the present state of the law shipowners were practically irresponsible for loss of life by shipwreck if they carried the number of boats at present prescribed by act of parliament. If it were demonstrated that by the adoption of the Berthon boat passenger ships would be able to carry a sufficient number of boats to hold all the people on board, the blame would be upon shipowners in the event of loss of life being occasioned through a deficiency of boats. Nothing will bring about a change in this respect but a change in the law. That noble pattern of humanity, Admiral Sir William Mends, had said that he never saw a troopship go to sea without a sigh and a pang, for while there might be two thousand men, women, and children on board, the vessel could only carry fourteen boats, and these would carry only 550 people. During the last five years all the troopships have carried a sufficient number of Berthon boats for 600 men, besides the usual supply of boats of the ordinary character. He hopes the time is not far distant when all passenger ships will be required to carry adequate boat accommodation for all persons on board. The Berthon boats are made in all forms and in all sizes, and are constructed for pleasure purposes as well as for the saving of life. They have been adapted to the saving of the lives of crews engaged in the most dangerous of all possible expeditions—namely, torpedo craft service. At the instance of Admiral Ryder, Mr. Berthon has devised a form of boat suitable for this purpose, and in consequence of the limited space available for storage, these boats are made in halves, the division being transverse. All the torpedo boats belonging to England are now furnished with this form of divided boat, and the French Government, the Italian Government, and two or three others have followed suit. Only on the day of the lecture he received an order from the Greek Government to supply twenty-one of the boats for the torpedo craft in the Piræus, and several have been ordered for the Chinese. A large boat, 31 ft. by 8 ft. 3 in., in three parts, so as to be stowed between decks out of the reach of an enemy's shot, is carried by H.M.S. Inflexible. This boat is remarkable for its carrying power, as well as its excellent sea-going qualities, and stands up well under an amount of sail that would be dangerous in common boats. Our engravings, from the *Engineer*, show the boat of the Spartan stowed against the ship's side with sails, oars, and water breakers. The boat is also shown opened at the ends of the davits and ready for launching. When stowed it is covered by a tarpaulin—shown partly cut off—and occupies a space only some inches thick. The remaining engravings are a sheer plan and cross section. Our engravings were sketched from the boat as exhibited, combined with a wooden structure representing a portion of the Spartan's side.

THE WEEHAWKEN TUNNEL.

THE New York, West Shore and Buffalo Railway commences at Weehawken, New Jersey, on the Hudson River, opposite New York City, passes through the hills, turning to the north, keeping along the line of the Hudson River, striking Haverstraw, West Point, Newburg, Kingston, and at Coeymans Junction, dividing, the main line going to Buffalo, and the branch to Albany. The hills upon the west side of the Hudson commence in a small ridge opposite New York Bay, and extend in a northerly direction along the bank of the river, and at varying distances from it. All the railroad lines reaching New York City through New Jersey have found a formidable barrier in this ridge, and when the height prevented an open cut, have been obliged to resort to tunneling.

During the early part of this week we visited the tunnel at Weehawken, now being built by the above mentioned company, under contract with Messrs. Smith, Ripley & Coleman, and under the guidance of the superintendent, Mr. J. P. Stanton, thoroughly inspected the work. Extensive dock facilities, designed for the accommodation of both passenger and freight traffic, are now being constructed at the river end. There will be twelve piers, of ample size to permit of the easy handling of freight, separated one from the other by deep water slips. Tracks lead from the tunnel to each of the piers. South of these is the passenger station and ferry, one line from which will land at the foot of Forty-second street, and another line will go down town to a point not yet determined. Just south of the station a round-house will be located. Such additional tracks and shops as may be necessary will be placed on the meadows at the New Durham end of the tunnel.



PROFILE SHOWING COMPLETED SECTIONS

The profile shows the contour of the hill, and the positions of the portals and of the shafts. Work was begun just fifteen months ago, and five shafts have been sunk from the top of the hill to the grade line of the tunnel. From the foot of these shafts work has been pushed in both directions, with the exception of No. 5, in which, owing to its location, progress is only made in an easterly course.

These shafts were sunk the following depths:

No. 1 east portal	140 ft.
" 2	145 "
" 3	160 "
" 4	140 "
" 5	88 "

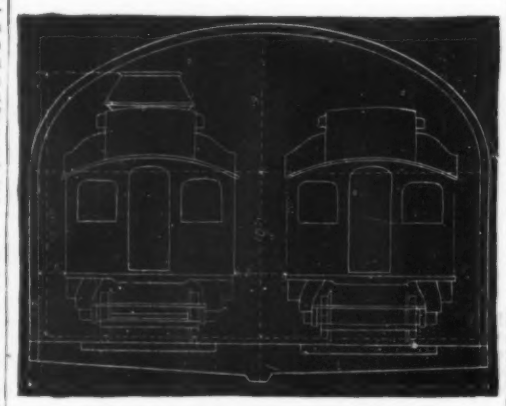
The cross-section measurements are 8 by 16 ft.

Descending shaft No. 1, we visited the eastern heading to examine the method of excavating. Five Rand drills were at work, rapidly opening a receptacle for a dose of high explosive, whose pent-up forces were to be liberated by the agency of electricity. All the men leave the tunnel when a charge is to be exploded, returning after things have quieted down. The loose material is placed upon cars running upon two tracks, which are laid as rapidly as the heading advances, and pushed to the bottom of the shaft. The hoisting machinery consists of a Copeland and Bacon engine, located in a little shed at the mouth. Two wire cables extend from the drum of the engine to two platforms, so placed in regard to the ropes that one is descending while the other is ascending. The loaded car is run upon one of these, raised to the surface, where it is taken by a locomotive to the place assigned for its load. To relieve the work of water a Worthington pump is placed at the foot of each shaft, and is supplied with steam by the boilers at the mouth.

Air for the drills is furnished by five Rand compressors, placed at the eastern side of the work.

No support will be required for the roof of the tunnel for about three-quarters of its length; the remaining portion will be supported by brick masonry two feet thick, and set in Portland cement. From the base to the beginning of the arch excavated rock will be used. The method of bracing is by beams of wood. When a sufficiently firm resting place cannot be found at the spring points of the arch, vertical pieces are added, which are supported from the bottom. These timbers are 12 by 14 in., and so placed as to admit of the brick-work without their removal. Additional security is obtained by running other timbers above those already mentioned, but in a longitudinal direction.

The tunnel is 27 ft. wide, 21 ft. high—or 19 ft. from the top of the rails to the center of the arch—and the roof semi-elliptical. A cross section is given with a maximum engine and car. The distance between the centers of the track will be 13 ft., the clearance between cars 3 ft., and between the side of the cars and the wall 1 ft. 6 in.



CROSS SECTION OF TUNNEL.

Rapid progress has been made since the commencement of the operations just fifteen months ago, the amount now finished being shown in the shaded portions of the profile drawing, Fig. 1. The rate during May in the east heading of shaft No. 1 was 66·5 ft.; timbering delayed operations in the other heading. The combined progress of both headings in shaft No. 2, was 65 ft.; shaft No. 3, 100 ft.; No. 4, 96 ft.; and in No. 5, 66 ft.; making a total for the month of 393 ft. The total amount now finished is 2,429 ft. and there remains to be done 1,571, making a total length of 4,000 ft. The amounts finished at each shaft are as follows:

From east portal to shaft 1	460 ft.
" shaft 1 to shaft 2	321 "
" " 2 " " 3	315 "
" " 3 " " 4	326 "
" " 4 " " 5	149 "
Total of	1,571 ft.

Extending from the eastern to the western portal on the summit of the hill is a railroad, crossing the morass shown in the profile by means of a trestle, with side tracks at each shaft. Near the western extremity are three Blake crushers. The crushed rock is thrown over the western side, and will be used as ballast when needed.

At the western approach we found two steam excavators at work—one upon each track. The rock is loosened immediately in advance of the machine by blasting, when it is lifted and dumped into cars, which are hauled by a locomotive to the dumping ground.

A short distance from the western portal the rock suddenly dips, forming a basin. This was filled with sand, covered with a layer of clay. Much trouble has been experienced from the water, and a trench 2 ft. by 2 ft. 6 in. has been built to carry the surplus away. This relieved the work to a certain extent, but as the water still gave much trouble while excavating, a system of piling was adopted. As the water flowed from north to south through the depression, it was proposed to sink two systems of short piling, seven feet apart, about half filled with stone, as shown in the illustration. The filling has been omitted, and only the piling driven. This plan is being carried out on the north side of the cut, and has resulted in an almost perfect exclusion of the water from the work.

The approach cut to the western extremity will be 2,700 ft. long, and is being rapidly pushed toward completion.

The approximate quantities excavated and to be excavated are: In the tunnel, 80,000 cubic yards; in shafts, 3,000 yards; and in the approaches, 180,000 yards.

In order to avoid sharp curves, the mouth of the eastern portal will be trumpet-shaped, the enlargement beginning about 100 ft. back. The increase will be to 50 inches width, and a proportional height.

The force consists of an average of 450 men in the tunnel, working in two shifts of twelve hours each. The number on the approach is 200. The plant consists of 5 Rand compressors, about 50 Rand drills (in operation day and night), 4 locomotives (2 at the western approach, 1 on top and 1 at the east end), 2 steam excavators, 3 Blake crushers and boilers, hoisting engines, and electric light apparatus at each shaft.—*Engineering News.*

CREDIT is due to *La Lumière Electrique* for the particulars and engravings of the Channel Tunnel, published in SCIENTIFIC AMERICAN SUPPLEMENT, No. 330. We may state that positive directions have always been given the members of our staff who translate or otherwise prepare matter from our contemporaries always to give due credit for the same. That it was not done in the cases referred to was simply an inadvertence.

ACID AND CHALK FOR DEFENSE.

DR. SIEMENS proposes to defend the Channel Tunnel, if constructed, from hostile invasion, by placing the shore ends in communication with chambers filled with lumps of chalk, and to connect each of them by means of a pipe with a large cistern filled with dilute muriatic acid. Upon opening the communication this acid would flow into the upper portion of one of the chambers, and be distributed by perforated pipes over the chalk, giving rise to a rapid generation of carbonic acid gas, which would for half a mile or more form an insuperable barrier to the passage of human beings through the tunnel.

A VISIT TO THE CREWE RAILWAY WORKS.

THE members of the Manchester Association of Employers and Foremen lately visited the Crewe Works of the London and North-Western Railway Co., and special arrangements had been made by Mr. F. W. Webb, the locomotive superintendent and chief mechanical engineer, to render the visit as interesting as possible. A correspondent of the *Colliery Guardian* says that the party numbered about a hundred, and the inspection of the extensive works, which have recently been extended by the erection of a new foundry, undoubtedly one of the largest in the world, entailed a thoroughly hard day's work on the part of the visitors. It would be impossible to attempt any detailed description of the works or the varied plant which they contain, and we can only sketch very briefly some of the leading points. The feature which probably impressed most deeply the minds of the visitors was the excellent system and general order maintained throughout the works, and the almost complete absence of what may be termed hard manual labor, by the employment of an infinite variety of machinery for manipulating nearly every piece of work. Mr. Webb being unavoidably absent during the earlier portion of the day, the visitors were received by Mr. Charles Dick, chief indoor assistant superintendent, and conducted through the works. The arranged route commenced with the fitting shop, where specimens of the locomotive cylinders now cast in pairs were seen. By this arrangement the cylinders are not only produced at less cost, but the joint, which was always a source of trouble in the old cylinders cast singly, is dispensed with. In connection with the new cylinders special machinery has been designed for planing up the valve faces, and for boring the steam ports, which attracted considerable interest. Passing on to the wheel and axle shop, a number of excellent tools were seen in operation, including a crank turning lathe with seven tools, and a machine designed by Mr. Ramsbottom, the locomotive superintendent, for roughing out the throws of cranks, and a quartering machine designed by Mr. Webb for boring out the crank-pin holes and wheel bosses with fixed centers, so that all crank-pin holes bored out by this machine are a facsimile of each other. There was also a hydraulic wheel-press, designed by Mr. Webb, for forcing wheels on the axles and insuring their being at the proper angle. In the same shop the light traveling jib cranes for lifting the wheels and axles into the lathes and other machines were very interesting pieces of mechanism. These cranes travel along a single rail on the shop floor, parallel with the lathes, etc., and are supported at the top by guide rods in the roof. They are driven by a light cotton cord about ⅝ in. diameter and travel along the floor at the rate of 80 ft. per minute, and lift their loads at the rate of 9 ft. per minute. In No. 3 and 4 erecting shops the operation of removing an engine by means of a couple of overhead cranes, worked by power and under the control of one man, was witnessed. An excellent collection of hydraulic riveting apparatus, both for heavy and light work, slotting machines for dealing with eight locomotive frames simultaneously, and drilling machines by which four frames are drilled at the same time, were also at work, and it may be added that these frames are entirely of steel and are rolled in one plate. The smithy and forge, which contain 113 smiths' fires and nineteen steam hammers, ranging from 2½ cwt. to as many tons, were next gone through, and among the special appliances here were a machine for drawing off the buckle from old springs by hydraulic power without injuring the buckle, and another hydraulic machine for fixing on the buckle to new springs. The system of forging by means of dies under the steam hammer was also much admired, and the specimens of forgings which were to be seen were exceedingly clean; in fact, with many of them very little further tooling is required. The extensive joiners' shops and saw mills could only be rapidly passed through, and here were the most modern of wood-working tools, designed both for rapidity of work and economy in manipulation, an illustration of which was afforded by the taking out in one solid piece of timber, to be afterward utilized, the portion of a signal post in which the semaphores are fixed. The millwrights' shop, in which the manufacture and repair of shafting, and the construction of cranes, warehouse machinery, and stationary engines is carried on, would form a not unimportant engineers' work of itself, and is fitted up with all the general class of modern tools. The party next proceeded to the steelworks, which are capable of producing 30,000 tons of steel per annum, and the Bessemer and Siemens-Martin processes of making steel were seen in operation. Then on to the rolling mills, the first object of interest being a 14-in. mill rolling fishplates, which were passed on to machines for sawing, filing, punching, and straightening. The rolling of steel rails, and straightening, drilling, and ending machines were also seen at work, and then passing on to the point and crossing shop, a number of machines were open to inspection which had been specially designed for this class of work, and which, by the novelty of their arrangement attracted general attention. The boiler shop also contained a collection of special plant of the highest class, and attention was directed to Mr. Webb's patent for flanging the outside and underside plate at the firing hole, so as to dispense with the ordinary water-ring, which is certainly a very great improvement. This alteration requires a special machine, which has been well designed, for drilling both plates at the same time, and a special riveter has also been introduced for riveting the fire-hole door. It may be here added that the high class material manufactured at Crewe enables it all to be manipulated by flanging machinery, and the boiler ends forming the front, as well as other portions of the fire-box plates, are flanged in one heat by hydraulic presses in a few seconds. One very powerful hydraulic machine which attracted attention was a press by which the fire-door hole, measuring about 3 ft. by 2 ft. 6 in., was punched out of the plate cold in one operation. In doing this the plate is brought in contact with the punch by hydraulic pressure of 350 lb. to the square inch; this is, then, by means of an intensifier, increased up to 1,800 lb. to the square inch, at which pressure the punch is carried through the plate. The 5, 6, 7, and 8 erecting shops contained mounted boilers, and a number of special machines made at Crewe. These included machines by which six horn blocks are refaced on both sides at the same time, and the machines being supported on the locomotive frames by templates, correctness of all the centers is secured. There were also machines for re-boring the cylinders in place, and re-facing the valves, the whole of the machines being driven by a cord from the line shaft. The new foundry which has just been added to the works, and which covers a site of 420 ft. by 120 ft., was next visited. The foundry has not yet got into operation, and was occupied by a collection of the work manufactured at Crewe. In designing this structure special care has been bestowed upon the lighting and ventilating of the building, windows and lights being provided at the sides and top. The roof is in three spans, each span being in two sections, and between the top of the lower section and the eves of the upper section a space is provided along the whole length of roof for the escape of smoke, steam, and other gases. Two rows of iron pillars support the roof and serve to divide the building into three longitudinal sections. Close to the pillars are others which support girders running the whole length of the building. These girders and the tops of the side walls are each surmounted by a rail, thus providing three pairs of rails for overhead traveling cranes. Two cranes capable of lifting 10 tons, which have been supplied by Messrs. Craven Bros., of Manchester, and four 5-ton cranes, made at the works, have already been put up. The foundry is to be provided with five cupolas, and under the platform at both ends are capacious drying stoves, and the foundry throughout will be fitted with the most modern and approved appliances. At one end of the building is a pit in which it will be possible to make, vertically, a casting of 40 ft. long, and hydraulic power will be provided for lifting out the metal. The whole of the foundry machinery will be driven by a wall engine, and the steam will be supplied by three locomotive stationary boilers, which will obviate the necessity of tall chimneys. In the engine room are two of Roots' patent blowers supplied by Thwaites Bros., of Bradford, from either of which a powerful blast may be obtained for any of the cupolas at will. The foundry has been designed by Mr. Webb, and the whole of the work has been carried out by the company's own staff of workpeople. From the new foundry the party proceeded to the steel and the iron forges, in which were shearing machines, a plate mill rolling steel locomotive frame plates, an axle mill, a toothless saw cutting steel angles (cold), which was watched with considerable interest, an 8-ton hammer forging crank axles, a 50-cwt. hammer forging piston rods, a 30-ton duplex hammer for boiler-plate slabs, a 10-ton duplex hammer for jumping wagon tires, a 50-cwt. hammer for punching, and a 5-ton hammer for beeking the tires, a tire rolling mill, and 7-ft. saw for bot slabs. In the iron forge were a 3-ton and 50-cwt. hammers, 14-in. and 6-in. guide mill-working saw and scrap-cutting and cleaning machine. The day's proceedings were agreeably broken by a visit to the Mechanics' Institution, which is practically in connection with the works, and where the visitors were entertained to luncheon provided by Mr. Webb. Afterward an inspection of the building was made, and one feature which elicited general approval was the transformation of what had been a bowling alley into a machine shop, fitted up with various tools, which will be driven by a gas engine, and where the members will be at liberty to make models, execute repairs, etc., and which, for the young members especially, will serve as a most excellent school in practical mechanics. Tea at the Royal Hotel brought the excursion to a close, and Mr. John Craven, the president of the association, in proposing the usual votes of thanks, gave a few details as to the extent of the Crewe Works, which, he said, occupied an area of 85 acres, of which 27 acres were covered in by buildings. 5,970 men and boys were employed, while the entire department under Mr. Webb's charge numbered 14,975 employes, and the pay sheet for that week amounted to £18,000.

BIG LOCOMOTIVES.

WE have so frequent inquiries about the size and weight of the largest locomotives that we give herewith the weight and dimensions of the heaviest freight and passenger engines that we know of that are in use in this country:

Name of Railroad or Builder.	Kind of Locomotive.	Total weight.	Weight on driving wheels.	Diameter of driving wheels.	Size of cylinders.
PASSENGER LOCOMOTIVE.					
Reading Railroad	Fast Express	96,200 lb.	*64,250 lb.	68 in.	21 × 22 in.
Pennsylvania Railroad	" " Class K	92,700 "	*65,300 "	78 "	18 × 24 "
	Fontaine Locomotive	93,000 "	†44,000 "	.....	16 × 24 "
Baldwin Locomotive Works	Fast Express	85,000 "	†35 to 45,000 lb.	78 "	18 × 24 "
Boston and Albany	" "	80,000 "	†56,000 lb.	66 "	18 × 22 "
Pennsylvania	Tank Locomotive	‡120,400 "	.....	60 "	17 × 24 "
FREIGHT LOCOMOTIVES.					
Reading Railroad	Consolidation	102,000 "	88,500 lb.	50 "	20 × 24 "
" "	Twelve wheels coupled	101,000 "	101,000 "	46 "	20 × 26 "
Atchison, Topeka and Santa Fe	Consolidation, tank	§115,000 "	§100,000 "	48 "	17 × 24 "
Central Pacific	Mogul tank	.....	88,000 "	48 "	16 × 24 "

* On four wheels. † On two wheels. ‡ Reported weight. § Estimated.

YANKEE STEAMERS BUILT IN ENGLAND.

THE *Glasgow Herald* gives the following particulars of the paddle-steamer Ho-nam, which made her trial trip on the Clyde on Saturday, the 27th of May, with results on which her builders deserve hearty congratulations: "On Saturday the paddle-steamer Ho-nam proceeded down the Firth of Clyde on an experimental cruise. The new vessel was constructed by Messrs. A. & J. Inglis, Pointhouse, for the Hong Kong, Canton, and Macao Steamboat Company, and she is intended for passenger service between Hong Kong and Canton. She is 280 feet long, 73 feet broad, and 30 feet in depth to the upper deck. Her gross tonnage is 2,364 tons, and she possesses accommodation for about 2,000 passengers. In outward appearance she bears a strong resemblance to an American river steamer, the promenade and saloon deck rising to a considerable height above the bulwarks and covering the whole vessel fore and aft. One of the peculiarities of her construction which at once attracts attention is the enormous diamond-shaped beam rising above the highest deck and forming a very marked feature in her appearance. There are altogether three decks—the main, promenade, and saloon. The forward part of the promenade deck consists of state rooms of the luxurious dimensions of 9 ft. square and 7 ft. 6 in. high. These give accommodation for about two dozen first-class passengers, and they are fitted with large windows and all the necessary ventilation for the climate in which she is intended to run. The highest or saloon deck is open, and covered with an awning, and it is intended as a promenade for the passengers. The engine is also of a novel construction, being a compound beam engine, the beam being the part we have mentioned already as forming a notable feature in the appearance of the vessel. The engine is of about 3,000 indicated horse power, the cylinders being 40 in. and 72 in., by 10 ft. stroke. It is this great length of stroke which necessitates the rising of the beam to such a conspicuous height. The paddle-wheels are fitted with feathering apparatus and steel floats. Messrs. Inglis have had great experience in building vessels of the type of the Ho-nam, having constructed nine paddle-steamers for China river navigation. This service was for many years carried on by steamers of American build, but in the year 1868 the most important American company in China, attracted by the favorable conditions for shipbuilding which the Clyde can offer, intrusted the building of the steamer Hupeh to Messrs. Inglis. The marked success of this vessel led to the construction of the Shingking for the same owners; the Pekin, Shanghai, Hankow, and Ichang for Messrs. Butterfield and Swere; the Kiang Kwan and Kiang Yung for the China Merchants' Company; latterly of the Ho-nam for the Hong Kong and Canton Company, and a still larger vessel, not yet launched, for the China Merchants' Company. The superiority in speed, carrying capacity, and durability of the Clyde-built iron and steel steamers over the American wooden vessels has driven the Yankee builders completely out of the market. The Ho-nam is a great advance upon any previous vessel in point of speed, having been built to perform the run from Hong Kong to Canton and back in one day. No vessel at present in China can do more than the single trip. For this purpose a speed of at least 15 knots was necessary, whereas 12½ knots was formerly considered a maximum. The Ho-nam has a considerable margin over this requirement, having attained a speed of 16·142 knots on the measured mile at Skelmorlie. The speed trial having been completed, the consumption of fuel was carefully measured for several hours, a mean speed of 15 knots being maintained during the whole time. The result of this trial was highly satisfactory, being within the contract limit. The trials were superintended by Messrs. Kottgen and Beyar, agents in London, and Mr. Roy, superintending engineer. The vessel proceeds to China next week, under command of Captain Barnet, who has navigated several of these steamers abroad with much success."

A LIVERPOOL ICE MANUFACTORY.

A NUMBER of gentlemen were recently afforded an opportunity of witnessing the working of the extensive plant which the Liverpool Pure Ice Company (Limited), of 24 North John street, have just laid down at their works situated at the Duke's Dock. The works are equal to the production of 35 tons of ice per day, and the process of manufacture is a most interesting one, and curiously suggestive of the marvelous resources of chemical science and mechanical skill. The ice is produced in blocks of the most perfect transparency—"clearer than crystal"—and fully warrants the term "pure ice," in contradistinction to the impure ice which finds its way into the market and too often into table use. It is also a more solid body than natural ice, even, apparently, than that from the famous Lake Wenham. The advantage is claimed for the manufacture of artificial ice that the purity of the water can be determined beforehand, and the water used by the Pure Ice Company is the ordinary drinking water of the people of Liverpool; but, as not even Rivington water is absolutely pure, the apparatus in use at the Duke's Dock is fitted to remove every vestige of impurity; hence the adamantine-like purity of the blocks which it turns out. The entire plant has been constructed by Messrs. Emmerson, Murgatroyd, and Co. (Limited), engineers, of Stockport, on Raoul Pictet's patent, for which they are agents, from the designs of Mr. W. H. Beck, C.E., of 139, Cannon street, London. The cooling agent is sulphurous anhydride, a substance which can easily be converted from the liquid into the gaseous state and *vice versa*. It is while changing from the liquid to the gaseous state that heat is absorbed by it and cold produced. A large boiler supplies steam for working the freezing machine, the agitating gear for the effecting the transparency of the ice, for pumping water for condensing purposes, and for drawing the ice-blocks out of their moulds. The freezing machine itself consists in the first place of a condensing steam engine of about 50-horse power. This steam engine drives a double-action compressing pump for rarefying and compressing the sulphurous anhydride. In the second place there is a copper tubular condenser wherein the sulphurous anhydride is converted into the liquid form by the combined action of the pressure brought about by the compression pump and the cooling effect of a stream of cold water passed through the condenser. In the third place there is a copper tubular refrigerator of construction similar to the condenser, but immersed in a large underground tank. In this refrigerator the sulphurous anhydride which flows back into it from the condenser in the liquid form is converted into the gaseous form by the rarefying or exhausting action of the pump, the reduction

of the temperature, or, to speak popularly, the cold produced by that conversion into gas being transmitted to a quantity of brine which is caused to circulate through the tubes of the refrigerator in the same way as water is passed through the tubes of the condenser. In the fourth place there is a large underground tank, carefully insulated from the surrounding earth, and containing the moulds in which the blocks of ice are frozen. This tank is divided by longitudinal partitions into three divisions, in the center one of which is placed the refrigerator above mentioned. Two screw propellers, similar in form to those used in steamships, caused the brine to circulate backward and forward from end to end of these divisions, passing in its course through the tubes of the refrigerator where it is cooled, and against the sides of the moulds containing the water to be frozen. Each of these moulds has a capacity sufficient to contain two blocks of ice each 3 feet long, 1 foot 6 inches wide, and 7 inches to 7½ inches thick, weighing from 1¼ to 1½ cwt. each. If the water was allowed to freeze in the moulds without special means being used to prevent it, the ice would be white or cloudy, more like snow in appearance than ice. In order to overcome this, the water in the moulds is kept in motion while it is freezing up to the last moment of finishing the blocks, by an ingenious arrangement of reciprocating paddles worked by a special steam engine. Travelers are arranged to run over the whole extent of the tank, and by their aid the moulds containing the finished blocks of ice are raised out of the congealing tank and conveyed to the thawing tank containing hot water, into which they are dipped for a few seconds in order to free the blocks from the sides and ends of the moulds. The moulds with their contained blocks of ice are then placed on tipping tables, which are turned over into an inclined position, and the blocks of ice slide out on to a stage, from which they are conveyed to the stores which are contiguous to the ice-making apparatus. Such is the process by which the Pure Ice Company propose to supply Liverpool with ice all the year round at a cheap rate; and as the demand is large and increasing, their venture will doubtless prove a successful one.

NOBEL'S EXPLOSIVE GELATINE.

IN the elaborate report by Lieut. Col. Henry L. Abbot, of the U. S. Corps of Engineers, upon Experiments and Investigations to Develop a System of Submarine Mines for Defending the Harbors of the United States, we find some data on Nobel's new "Explosive Gelatine," which we understand is to be manufactured in this city, by the Atlantic and Pacific Powder companies. The sample tested was made in December, 1880, by Professor Hill, of the Naval Torpedo Station, at Newport. It consisted of 89 per cent. of nitro-glycerine, 7 per cent. of collodion gun-cotton, and 4 per cent. of camphor. It was forwarded in slabs wrapped in oiled paper, each weighing about ten pounds. Being received in midwinter, it remained frozen in the magazine until April 18, 1881—a whitish opaque solid of about the consistency of cheese. Small pieces in this state, lashed to a service low-tension fuse primed with twenty-four grains of fulminate of mercury, failed to explode; and the same results followed when three of the fuses were fired simultaneously in contact.

In April, the slabs were moved to a wooden shed with the papers unwrapped, and under the influence of the spring weather they soon began to thaw, changing in appearance into a thick semi-transparent jelly of a pale yellow color. The substance in this condition possessed considerable toughness, but could easily be cut with a knife and rolled in strips. Its specific gravity was about 1·6, or nearly that of dynamite No 1, compacted in cartridges. A couple of ounces laid on a zinc plate and exposed for about six hours to a hot sun, when the thermometer in the shade indicated 90° Fahr., softened sufficiently to flatten by gravity, but no oil exuded, and when ignited by a match, the mass burned like gun-cotton, with a strong hissing flame. A small piece plastered upon the copper cap of a service fuse exploded with a loud report, indicating an increase in sensitiveness.

In only one instance (May 10, 1881) was any important exudation of nitro-glycerine noted, when about half a dozen drops appeared by the side of one of the thawing slabs; but the surface of the mass in this condition was usually oily; and by absorbing with paper and striking with a hammer, a sharp explosion could be obtained, proving the presence of free nitro-glycerine. Handling the jelly always produced the customary nitro-glycerine headache.

The following experiments were made upon the gelatine. A slice half an inch in thickness was suspended in paper and pierced by a bullet from the regulation Springfield rifle, fired at twenty five yards; result, *nil*. This experiment was repeated, with explosion, when the gelatine was backed by an inch board. The range was then increased to forty-five yards, and the bullet was driven with a like result through the explosive, and flattened on a half-inch iron plate against which it was resting. Finally, a ten-pound slab was lashed to a vertical board one inch thick, and was pierced by a service bullet at a range of one hundred yards. The ball thus traversed about three inches of the gelatine without effect. In all these trials, the explosive was in its semi-transparent, jelly-like condition.

To test its tendency to sympathetic explosion, a few experiments were carried out. Half-pound cartridges wrapped in paper were submerged five feet below the water surface, at distances of fifteen, ten, five, and three feet from a fuse can containing one pound of dynamite No. 1. Detonating the latter produced no effect upon the explosive gelatine. Under like conditions, dynamite No. 1 explodes up to a range of twenty feet.

These experiments confirmatory of those reported abroad, show that the new explosive possesses much less liability to accidental detonation than dynamite No. 1, an advantage which can hardly be overestimated.

This explosive gelatine proved to be wholly soluble in ether, and in a mixture of ether and alcohol, but in alcohol alone it dissolved with difficulty. Unlike its operation with other nitro-glycerine compounds, this process did not separate the oil from the base. By evaporation, or by the addition of water, a white mass was precipitated, which resembled thick flour paste in appearance. When subjected to moderate heat, a tendency to very gradually resume the semi-transparent appearance was developed.

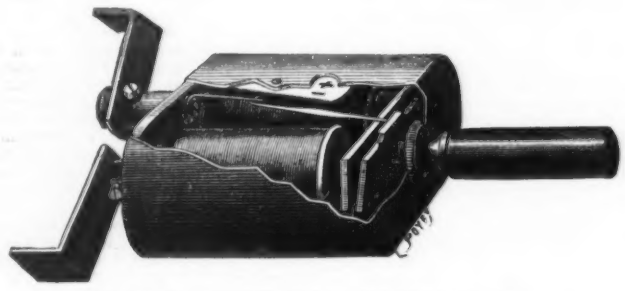
Water produced no exudation of nitro-glycerine, another important advantage over dynamite No. 1, from which, as already stated, it abstracts the nitro-glycerine to a greater or less extent, dependent upon the compactness of the material. After several hours' submergence, however, the color changed to the opaque white characteristic of the precipitation from ether.

All authorities agree that this substance is more difficult to detonate than dynamite; but a few trials on land indicated, when the gelatine is in a soft state, that a violent explosion could be caused by the service fuse charged with twenty-four grains of fulminating mercury contained in a copper cap.

Two of the shots were designed to test the effect of freezing the gelatine. The charges (three pounds) were placed in a soft state around the primings (one of gun-cotton and the other of loose dynamite No. 1), in No. 1 tin cans, which were then packed in ice for seventy-nine hours. The explosive assumed the appearance of a white solid, so hard that it could not be indented by a stick; but no effect was produced upon the normal intensity of action due to perfect detonation.

BELL FOR TESTING PILES.

IN certain applications there often occurs a need of a simple and quick process for successively testing and verifying the piles of an installation (on railways, for example) in regular service, so as to easily detect and replace the element that is not in good condition. The little apparatus that we are about to describe supplies such a want perfectly. The accompanying figure represents it in its actual size, and shows its principal arrangements. It consists of a small portable electric bell, in which the bell itself, in the form of a flattened cylinder, serves as a box for the mechanism. A handle fixed to the box serves for holding it, and for maneuvering it by bringing the two movable pieces attached to the terminals in contact with the two poles of the pile that it is desired to test. The electro-magnet hidden in the box attracts an armature to which there is attached a little hammer that strikes the back part of the bell. The interruptions of the current are made by the displacing of a small flat spring located in front, and which may be seen in the figure, where a portion of the box is represented as removed. The varying loudness with which the trial-bell rings indicates, after a little practice, the state of the pile



BARBIER & PIERET'S BELL FOR TESTING PILES.

submitted to the test; and the apparatus performs at once the *role* of galvanoscope and acoustic galvanometer. The apparatus, which is very compact, may be put into one's pocket, and gives a means of verifying a very large number of elements in a very short space of time. It has been gotten up for testing Leclanché piles on railways. The completest apparatus (and the figure represents one of that kind) are provided with a small wicket, before which appears the sign + or —, according to the direction in which the current is traversing the apparatus, and indicates the name of the pole connected with the foremost terminal of the box to the side of the wicket. This result is obtained very simply by means of a small strip of magnetized steel which is affixed to the box, and which, under the action of the current traversing the electro-magnet, approaches one pole or the other.

This very simple arrangement will prove of value when a system of electric call-bells, lighters, etc., is to be put up, and the precaution has not been taken to indicate the poles by conducting-wires of different colors.

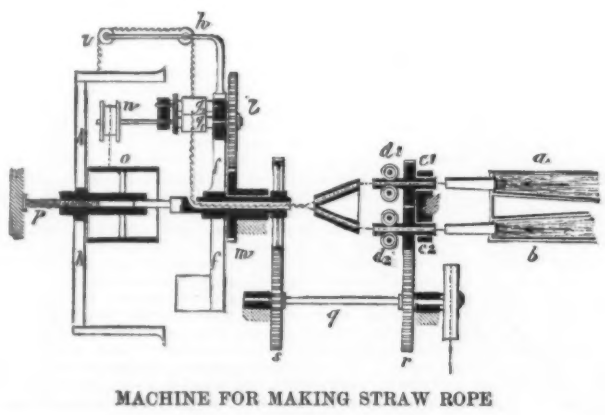
The apparatus may be used, also, in the coupling of secondary piles, to indicate accurately the direction in which they are charged, and obviates all errors in mounting.

When the terminals of the apparatus to be tested are too distant from each other, it is well to adapt to one of the movable pieces of the terminal of the trial-bell a flexible insulated wire of suitable length, terminating in a small copper or silver rod that may be applied against the most distant terminal of the element to be tested. As at present constructed, this little apparatus of Messrs. Barbier & Pieret seems as if it ought to render useful services to those who have, every day, to group and test numerous pile or accumulator elements.

MACHINE FOR MAKING TWO-STRAND STRAW ROPE.

AMONG the rare machines for twisting, protected by a patent, we would call attention especially to one for manufacturing two-strand straw rope, and which is the invention of Messrs. Söeborg & Petersen, of Röskilde, Denmark. In this apparatus, which is shown in the accompanying cut, the straw, placed in two separate compartments, *a* and *b*, is fed to the two little tubes, c_1 and c_2, which are given a rotary motion. In these it is converted by the small cylinders, d_1 and d_2, into two strands of slight compactness. These two strands unite just before they enter the hollow axle of the revolving fly-wheel, *f*, and issue from this axle through a lateral aperture after they have been twisted. The finished rope is led by the two driving cylinders, g_1 and g_2, and the guides, *h* and *i*, to the drum, *k*. The cylinders, g_1 and c_2, are supported by the fly-wheel, and receive their rotary motion from the wheel, *l*, which revolves with the fly-wheel and engages with the fixed cog-wheel, *m*. The rotary motion of this wheel, *l*, is transmitted to the drum, *k*, by a belt which passes over the pulleys, *n* and *o*, and which reduces the motion in the proportion desired. At the same time, the fixed screw, *p*, gives the drum, *k*, a slow motion parallel with the axle and proportional to the winding up of the rope. *q* is the driving shaft whose tooth-wheels, *r* and *s*, transmit the rotary motion to the tubes, c_1 and c_2, and to the axle of the fly-wheel.

The great compactness that is given the straw rope by twisting assures this machine of a certain importance from an agricultural point of view. This product, moreover, has for a long time found a useful application in the process of moulding in foundries; for wrapping steam pipes, and for other analogous purposes.



MACHINE FOR MAKING STRAW ROPE

THE LAWSON BOILER EXPERIMENT.

To the Editor of the Scientific American:

Concerning the recent Lawson boiler bursting experiment, I was particularly interested in the cuts and editorial remarks thereon in a late issue of your valuable paper. For years Mr. Lawson has been impressed with the belief that he had discovered, and would be able to successfully demonstrate, the true cause of boiler explosions. On a subject involving such world-wide concern the result was awaited with more than ordinary interest. Indeed, it was considered of sufficient importance to warrant the raising of a commission to witness the experiment and report thereon, which report, if it has ever seen the light, has escaped my attention. In the absence of such I may be pardoned for expressing the conviction, even after admitting the boiler was perfect, that there was no lack of water, and that the application of the device sought to accomplish it did not weaken the boiler, that nothing beyond bursting the boiler under certain well-understood conditions has been accomplished—conditions which you rightfully say were immense exaggerations of the most vicious practices in the use of steam boilers. In other words I maintain it is not a safeguard against the only two classes of accidents to which steam boilers are subject, viz.: bursting and explosion. Between the two there is a very wide difference, both in the producing cause and result. Why, since they are both alike destructive, draw a distinction, will appear further along. To successfully guard against the former perfection of material and construction is the requisite, while exemption from the latter depends alone on the water supply; how to distinguish between the two is just as easy as to determine the tree by its fruit. In the case of bursting the damage is confined to the weak or defective portion of the boiler, and produces only what is termed a blow-out, not a blow up, while in the case of an explosion not enough is left of the boiler or boilers, as the case may be, to mark the spot where they once stood. This is not imaginary, but the result of actual observation. I have witnessed the giving way of defective sheets while under a steam pressure, as well as under the government hydraulic test, which only had the effect of producing what has been described. It must be a different cause, indeed, that does in the twinkling of an eye convert whole batteries of boilers into flying and death dealing missiles, hurling them hundreds of yards in every direction and demolishing everything in their course, and yet we are told all this is but the result of a weak or defective spot in the boiler. I shall not attempt to define it, since no eye ever has or can witness it. Neither is it necessary, since we know how to prevent it, the true character of the force capable of such mischief, how and when formed, and at what particular stage it flashes. I have thus, without the aid of fine spun theories or high sounding phrases, endeavored

to show the difference between bursting and explosions too often confounded. And while this view of the case is commonly accepted there are those who, while they would not underestimate the importance of keeping up the water supply, maintain that explosions result from defects mechanical or otherwise, in other words, there must be a starting point. How the argument may apply to a mere rupture is not difficult to see, but that there exists on the face of the globe a man, however expert he may be, who can collect together the shapeless and unrecognizable fragments of a battery of exploded boilers and tell us just where the weak spot or starting point was, I deny. And yet this must be done in order to establish the correctness of the theory. Otherwise, pray, how are we to determine, as between bursting and an explosion, which of the two causes existed? This is the nice point, and by far the most important phase of the case, involving, as it does, responsibility, pains, and penalties. If the bursting theory is correct then the water question is of secondary moment. It being of the first importance, I insist on the distinction, if for no better reason than its tendency to increased watchfulness on the part of engineers. The reasonableness of the position will be understood when it is known the government is using its best efforts to secure safety in the construction and management of marine boilers, and in proportion as progress is made in this direction may we look for a corresponding diminution of boiler disasters. To sum up, bursting may and does occur while under a legal pressure, and not a scarcity of water, in which case the engineer in charge cannot be held accountable. Far different are explosions which result from lack of water. The appliances for regulating the same are so reliable and perfect, that nothing short of inattention to duty can be accepted as the true cause of their occurrence, and the engineer, having forfeited his license, should, were life involved, consider himself fortunate if he escapes indictment for manslaughter. Does the Lawson patent meet the case? OHIO RIVER.

Wheeling, W. Va., May 29, 1882.

GLOUCESTER CATHEDRAL.

THE north-east view of Gloucester Cathedral, shown in our present issue, is a very good example of Perpendicular architecture overlaid upon a Norman building, the fine turrets of which show at each end of the transept. The Norman work was erected by Abbots Serlo, Peter, and Godemon, between the years 1100 and 1130, and the Perpendicular additions were made chiefly with the money offered by pilgrims at the shrine of Edward II., who was buried on the north side of the choir. The work was done by Abbot Horton and others about the year 1380, the tower being completed about 1455. The total height of the tower is 225 ft. For further particulars we refer our readers to the account of Gloucester Cathedral, from which this view is, by permission, taken, published by Mr. J. P. Moire, architect, Gloucester.—*Building and E. Times.*

GLOUCESTER CATHEDRAL FROM THE NORTHEAST.—DRAWN BY J. P. MOIRE.

THE SUBSTANTIAL PROSPERITY OF COLORADO.

By HON. THOS. M. PATTERSON.

. . . . FOR the twenty-seven years beginning with 1850, the money invested, the labor expended, and material used in mining for precious metals in the United States, are fairly estimated at $709,000,000, while the money returns therefrom, and created values in mines and mills, amount to $2,200,000,000, giving to the investors more than 200 per cent. as actual profit. Within the last twelve years the mining States and Territories have produced more than $875,000,000 of gold and silver bullion—the highest value of any of the years being $95,000,000 and the lowest being $52,000,000.

For the same period of twelve years the struggle for the supremacy in the contest of precious metals had been with California and Nevada. Like well-matched athletes, now one seemed to prevail, and now the other.

Colorado, though robust and aspiring, seemed a pygmy beside these giants, but in 1879 she took up the gauntlet, and from a product of $8,000,000 the preceding year, that year came to the front with more than $17,000,000. California gave to the world the same year $18,000,000, and Nevada contributed nearly $22,000,000. But their insignificant triumph of that year was their last. The infant had grown into a man—ay, it became a giant, for in 1880 Colorado from its river beds and mountains made the world the richer $23,000,000, while California and Nevada followed in the rear, the one with $19,000,000 and the other with but $15,000,000.

But, unapproachable as is our State in the production of the royal metals, exploration and experiment have shown that States gray with age and decorated with a century's industrial badges for achievements in the arts where coal and iron are used, have just reason to fear the rivalry of this youngest of the sisterhood in all branches of mechanical industry where the intervention of the humble metals is invoked. Colorado, while it leads the van in furnishing the material for the world's money—the metals of which crowns are made, and flashing coronets and tinsel, and fashion's baubles, is equally in the front with vast stores of what commerce terms the baser metals, but which in their universality of use and adaptability to every phase and necessity of a world's rugged and healthful wants are in fact by far the nobler.

The age of gold and silver in Colorado has been supplemented by the age of iron and coal. Pennsylvania, through its blast furnaces and coal beds, has become the second State in the Union, both in wealth and population. California, from its golden sands, has wrought itself into a giant commonwealth, the gateway to the Union for the commerce of the Pacific Islands, and 400,000,000 of Asiatic people. Colorado has within her borders the metals and minerals of both these great States in equal degree. While she has outstripped the one in the joint production of gold and silver,

she has of iron and coal that, which ere a generation passes, will make her the rival of the other, in that vast network of mechanical devices fashioned from them, which are so interwoven with human life that they form a part of its warp and woof. Every quarter and section of the State is pregnant with the wealth which forms the sum of its greatness. The golden fissures of Gilpin and Boulder, the silver fissures of Clear Creek, Summit, Custer, the Gunnison, and San Juan, are reservoirs of the two metals which will not be exhausted until the primeval curse dooming man to labor shall be revoked. The coal beds of Las Animas, Fremont, and Gunnison, the iron joined in nature's wedlock to them, the clays, silicates, timber, grasses, soils in every section of the State where the sun shines and the winds blow, make up a grand total of material elements which invites capital to profitable investment and labor to generous remuneration.

The world recognizes that Leadville is the most magical city of the age. From its mines and smelters more silver annually flows into the arteries of the world's commerce than is supplied by any entire State or foreign land. In Pueblo, with its vast steel works and iron furnaces, its product of Bessemer and pig, its proximity to vast beds of coal and iron, its railroad facilities and geographical position, we but anticipate the future Birmingham or Pittsburg of the great and growing West. In Denver we behold the Queen City of the mountains and the plains. For five hundred miles, north, south, and west, the continent pays constant tribute. Twelve lines of railway, which are still stretching out their iron arms to encircle new possessions, carry in and out the moving multitudes and distribute the contents of her warehouses and the products of her shops. She is without a rival, and envy has been silenced in her presence.—*La Plata Miner.*

THE THREEFOOT RULE.

A SONG ABOUT STANDARDS AND MEASURES.

Air: "The Poacher."

I.

When I was bound apprentice, and learned to use my hands,
Folk never talked of measures that came from foreign lands;
Now I'm a British workman, too old to go to school;
So whether the chisel or file I hold, I'll stick to my three-foot rule.

II.

Some talk of millimeters, and some of kilogrammes,
And some of deciliters, to measure beer and drams.
But I'm a British workman, too old to go to school;
So by pounds I'll eat, and by quarts I'll drink, and I'll work by my three-foot rule.

III.

A party of astronomers went measuring the earth,
And forty million meters they took to be its girth;
Five hundred million inches, though, go through from pole to pole;
So let's stick to inches, feet, and yards, and the good old three-foot rule.

IV.

The great Egyptian pyramid's a thousand yards about,
And when the masons finished it, they raised a joyful shout;
The chap that planned that building, I'm bound he was no fool,
And now 'tis proved beyond a doubt, he used a three-foot rule.

V.

Here's a health to every learned man that goes by common sense,
And would not plague the workman on any vain pretense;
But as for those philanthropists which send us back to school,
Oh, *bless* their eyes, if ever they tries to put down the three-foot rule.

—*William J. MacQuorn Rankine.*

EDWARDS' PROCESS FOR PHOTO PLATES.

We find the following in the Boston *Sunday Budget:*

At a meeting of the Boston Society of Amateur Photographers, Mr. Ernest Edwards communicated the result of some recent experiments of his own in the preparation of gelatine emulsion dry plates which excited much interest. Mr. Edwards said that it had long seemed to him that the ordinary process of producing dry plates was open to many objections, and that it was so complex that there was always great uncertainty as to the result. He exhibited three plates. The first of these was coated with a yellowish film, insensitive to light, but which could be made sensitive by soaking in cold water; the second was a plate that had been made sensitive in this way; and the third was a plate which, having been thus made sensitive, had been exposed under a negative to the action of gaslight for three seconds, and then developed with oxalate, producing an excellent transparent negative. The points gained by this process were that the emulsion was made and the plates coated wholly by daylight, and that the ordinary and tedious process of washing to get rid of the free nitrate of silver, the nitrate of potash, and other objectionable elements, was dispensed with. Mr. Edwards described the process in detail as follows:

He dissolved twenty-four grains of bromide of potassium and thirty grains of gelatine in half an ounce of water raised to and maintained at a temperature of 109° Fahr. Next, he dissolved thirty grains of nitrate of silver in two drachms of water, adding liquor ammonia until the black precipitate formed was redissolved, the amount of liquor ammonia added being thirty-five drops. This ammonio-nitrate solution was then added to the bromized gelatine solution first named, and the two thoroughly mixed by agitation. To this was added a solution of twenty grains of bichromate of potash in half an ounce of water, and, finally, two drachms of alcohol, raised to a temperature of 100° Fahr., were added to the mixture. *All these operations were conducted by daylight.*

Next, still working by daylight, the plates were coated by pouring, and laid aside to set and dry. When dry, one of them was taken into a dark closet, soaked in cold water, face downward, for about an hour, the water being changed several times, and then removed from the water and dried in the dark. It was then exposed under the negative and developed with the result above given. The action of the bichromate is to render the bromide of silver insensitive while it is present. The washing removes not only this bichromate but also takes out the free nitrate and the nitrate of potash, the thin film being the best possible form in which the gelatine can be presented for washing. All necessity for "cooking" the gelatine is done away with by the use of ammonio-nitrate.

Mr. Edwards recommends that in using plates by this process they be washed as soon as they are "set," without allowing them to dry, as in this way any effect that the light might have on the bichromated gelatine is avoided.

The importance of this new departure in the method of preparing dry plates can only be appreciated by those who have made them by the old method, which requires all the operations of mixing, "cooking," washing, coating, and drying to be carried on in a room so dark that it is impossible for the operator to clearly see what he is doing. With properly constructed washing and drying boxes, plates may, by Mr. Edwards' method, be made in large quantities much more rapidly and at much less cost than by the method now in vogue. It is hoped that others will experiment upon it, and make public the results of their investigations.

A NOVEL METHOD FOR THE INTENSIFICATION OF NEGATIVES.

THE intensification of line negatives is, notwithstanding the many excellent processes which have been devised, still a matter which frequently causes some considerable difficulty to the photo-lithographer. When the subject to be copied consists entirely of clear black lines on a white ground, it is quite easy to obtain a satisfactory negative, and intensification by almost any good process becomes easy; but the real difficulties step in when an attempt is made to obtain a negative of a subject in which fine discontinuous lines have to be reproduced side by side with bold and solid black strokes crossed closely together, as in such a case the fine lines almost invariably tend to become blocked up during the process of intensification. The usual proceeding in such a case is to expose fully, so as to secure the finest and faintest lines, and to take care neither to develop nor intensify so far as to block these with a deposit of silver; after which the negative is shaded on the back over those parts where the blackest lines are crowded and the intermediate white portions are grayish and ill-defined. This shading is generally performed with blacklead and a stump on a sheet of transparent paper stretched over the back of the glass, and this is repeated until it is found that the whole of the negative prints at about the same rate on a piece of photo-lithographic paper. Such a process is troublesome and takes a great deal of time, and the outcome is always a negative in which the available contrast is so feeble as to tax to the utmost the skill of the photo-lithographer in making his transfer.

A proceeding which bids fair to be of great practical value to the photo-lithographer in the reproduction of difficult subjects has recently been introduced by Schlegel. After the negative has been fixed and washed, it is coated with a thin layer of bichromated gelatine, and allowed to dry in the dark. When dry the plate is laid, face downward, on a black cloth, and is then exposed to the action of light. Under these circumstances those portions of the film immediately under the transparent parts of the negative become insoluble and lose the power of swelling in water. After a sufficient exposure has been given the negative is soaked in water, and suitable pigment is rubbed on—say permanent white, or any other substance which is fairly opaque—and this naturally only adheres to those parts which have become adhesive by the absorption of water. The great value of this method rests, however, on the facilities which it offers for local intensification, as the pigment need only be applied to those parts most requiring intensification, or which would have been shaded in the case we assumed just now.

Schlegel's process possesses considerable value for treating ordinary gradated negatives, and those who wish to modify the relative degrees of light and shade in various parts of the picture will appreciate the power placed in their hands by this method.

Our readers will at once recognize the fact that the process of intensification just described is founded on the same basis as the Anthrakotype process of Dr. Sobacchi, which was described in the *Photographic News* early during the past year. A gelatinous solution of the same strength (1 and 30) may be used in each case; but for the intensification of negatives by Schlegel's proceeding it is better to add the necessary proportion of potassium bichromate (say one-sixth part by weight of the gelatine employed), rather than render the films sensitive after they have dried.

It will be quite obvious that any of the ordinary dusting-on mixtures may be employed instead of the bichromated gelatine, but in such a case the plate must only be very gently breathed on, or merely exposed to a damp atmosphere before the application of the pigment, and it would be necessary to coat the intensified picture with collodion, and soak in water in order to remove the soluble materials used in the preparation of the so-called "dusting on solution."—*Photo News.*

RELATIVE SPECTRUM SENSITIVENESS OF PRINTING PROCESSES, AND ON A NEW FORM OF SILVER PRINTING PROCESS.

By CAPTAIN W. DE W. ABNEY, R.E., F.R.S.*

I PROPOSE to-night to speak on the relative spectrum sensitiveness of different printing processes, and then to introduce to your notice a modified silver-printing process. First, I propose to take carbon printing, and to give the results of my spectrum analysis of it. In a book that I published on photography, I mentioned that when using the original "Autotype" actinometer, in which silver-chloride paper was used to discolor to a certain depth by exposure to light when placed alongside the carbon print, in summer two standard tints were required, while in winter some five tints were necessary for the latter to be fully printed with a negative of ordinary density. I am aware that the effect of the spectrum on bichromate and gelatine has been studied; but, as far as I know, it has not been studied when the film was colored. I have therefore thought it advisable to examine the question, as to the reason of this requisite shorter exposure in summer than in winter. Through the kindness of the Autotype Company, at the beginning of this year, I was supplied with various samples of tissue which I had intended to utilize for my Cantor lectures. Unfortunately, however, my lectures closed without my having the opportunity of discussing the question of carbon printing; so I now venture to bring the subject before the society. Becquerel and others gave the spectrum impressed on bichromate and gelatine as extending from beyond F to the ultra violet; but I must say I was not prepared for the fact that the maximum of sensitiveness lay beyond F, more toward the yellow. Such, however, is the case. You will see by No. 2, that, with a short exposure, the maximum lies beyond F. No. 1 is the curve for different colored carbon tissues, such as is supplied commercially by the Autotype Company; and you will see that the spectrum impressed is a long one, and quite different to that impressed on the chloride of silver (No. 5). The maximum of intensity of the spectrum is in this last case between H and *h*, or at the borders of the violet and ultra-violet. It may be objected that the pigment used may have some effect on the sensitiveness; but the example before you shows that it is not the case—that it is the same exactly as in Nos. 1 and 2. The blue print on glass is ordinary gelatine, which was impregnated with bichromate and then printed in the spectrum. The blue is merely dye with which the film was impregnated *after development.* From this we learn that no solid pigment, at all events, alters the position of the maximum of effect of the spectrum. I doubt also whether a dye as a dye will do it. We thus have a very good explanation of the reason of the greater sensitiveness of the bichromated film over the chloride film, since the proportion of green rays to violet and ultra-violet rays in daylight is much larger in winter than in summer. Carbon printing, however, is more rapid than silver printing in summer, and much more so, therefore, in winter; it is, therefore, a gain at any time.

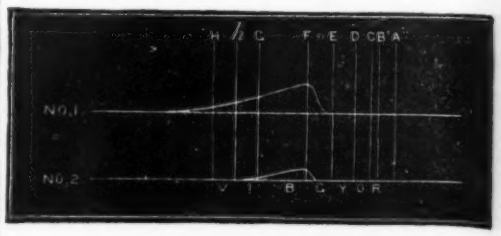


FIG. 1.—Nos. 1, 2, Spectrum on Bichromate of Potash.

I next come to the newer mode of printing—viz., platinotype printing. It will be in the recollection of the society that platinotype is based on the reduction of ferric oxalate to the state of ferrous oxalate. I have here a rough example of a gelatine plate impregnated with ferric oxalate; it was submitted to the spectrum, and developed with potassium ferricyanide. It is somewhat difficult to fix the place of maximum sensitiveness when using the electric light, since near G we have carbon bands of intense brightness; but I believe I shall not be wrong in taking the maximum one-third way from G toward F.

It was a matter of curiosity to find out if the platinum salt used had any effect. The print I produce shows three separate spectra, taken by sunlight, with varying exposures. It is evident that the platinum salt has no bad effect. The maximum is situated about the place I indicated, and extends as far as where ferric oxalate alone is used. This is a matter of some interest, since the same reasons apply for the rapidity of its printing in winter, over silver chloride. Carbon printing, however, ought to have an advantage in winter over the platinotype, though not much.

I have now to bring to your notice a process which may not be new, but which, at any rate, has the form of novelty to most. It consists of printing on a film of gelatine emulsion containing silver chloride and an organic salt of silver. You may take gelatine chloride and print on it, and the image will at once appear, full of vigor and of great beauty; but, when once an attempt is made to fix it, the image vanishes almost entirely, and, for printing purposes, unless the exposure is very prolonged indeed, is useless. In the old collodio-chloride process, introduced by the late Mr. Simpson, it will be in your recollection that citric acid is introduced in the presence of an excess of silver, and he expressly stated that its introduction was to give vigor. In fact, what is wanted is an organic compound of silver, be it albuminate or citrate, in order to give what is the foundation of vigor in all printing processes—an oxide of silver when exposed to light. Looking at it in this point of view, the old collodio-chloride process should in reality be called

FIG. 2.—Nos. 3, 4, Spectrum on Ferric Oxalate.

collodio-citrate or citro-collodio-chloride, but preferably Simpson-type.

With this object in view, I have made an emulsion of citrate of silver together with silver chloride. The method of preparation is as follows:

1.—Sodium chloride	40	grains.
Potassium citrate	40	"
Water	1	ounce.
2.—Silver nitrate	150	grains.
Water	1	ounce.
3.—Autotype gelatine	160	grains.
Water	3½	ounces.

Nos. 3 and 2 are mixed together, and then an emulsion formed by adding No. 1 in the usual way when forming a gelatine emulsion. When set, I squeeze the emulsion through canvas into cold water, and, after allowing it to remain in the water for ten minutes or a quarter of an hour, dissolve it up, with the addition of about 3 drachms of alcohol and 2 grains of chrome alum dissolved in 2 drachms of water. Plates or paper are then coated with the emulsion, and printing takes place in the usual manner. The rapidity of printing is very great; I think I may say that it is more than twice as rapid as ordinary albumenized paper. The image prints of a violet tint by reflected light, and of a rich chocolate color by transmitted light. If fixed without toning, the color of transmitted and reflected light is burnt sienna color,

* Read before the Photographic Society of Great Britain.

and of great vigor and beauty. Prints can be toned by any of the ordinary toning baths. Borax and chloride of gold give a pleasing tone; the sulphocyanide toning bath gives a black rather approaching an inky tone. Platinum can be used to tone the fixed print, but it has a great reducing action, and there is a tendency for the whites to become yellowed to a slight extent. For lantern slides or transparencies, the untoned picture would not be at all disagreeable. No doubt endless variations in the organic salts used might be made, but the citrate has answered well with me.

I hope the members of this society will try the process and improve on it. I think it has a future before it if properly taken up. I need scarcely say that the prints should be well washed. I doubt, however, if they would fade in the same way that albumen prints are so prone to do, as the organic salt used is a definite compound, and not one which is so complex and uncertain at the albuminate of silver is. I have in my possession prints made by Simpson-type more than thirteen years ago, and they are as fresh as the first day on which they were printed; not one has faded. The liability to fade is less with the above formula than with one which has an excess of silver present. The potassium citrate is in large excess; hence no silver will attack the gelatine. I ought to have mentioned that at first the emulsion may appear grainy; if, however, it be boiled for ten minutes, the grain disappears, for the silver citrate is soluble in warm water. The rapidity of printing by the boiling is certainly increased. The plates, when coated, are rather transparent, and *prima facie*, a vigorous print might not be expected from them. As regards the light to which it is sensitive, I must refer to the spectrum, No. 6, by which it will be seen that it is more sensitive to the blue and green rays than the chloride (No. 5).

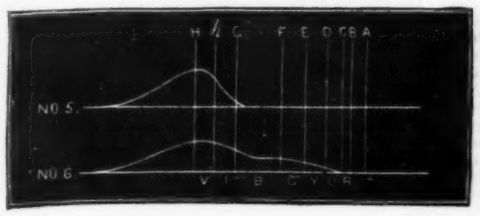
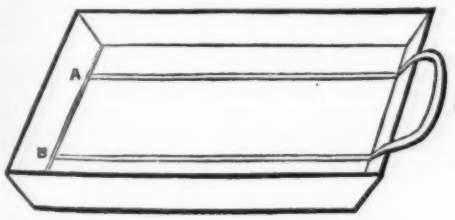


FIG. 5.—No. 5, Spectrum printed on Silver Chloride. No. 6, Spectrum printed on a mixture of Silver Chloride and Silver Citrate.

My last subject connected with printing is that of the discoloration of different sensitive salts by light. It has been assumed, I think, that a plate will not discolor so rapidly if chloride be absent as it would do if it were present. I hand for inspection plates containing a variety of mixtures, by which it will be seen that a plate containing nothing but bromide and iodide has, with me, discolored as much as a plate containing iodide, chloride, and bromide; even equal parts of iodide and bromide discolor deeply to a fairly-deep green-black color. Pure bromide, boiled and unboiled, takes but a slight color; while both boiled and unboiled chloride take the same dirty brown tone, which, however, as before stated, almost entirely disappears on fixing. Plate No. 1 is a mixture of bromide and chloride; No. 2, iodide and bromide; No. 3, chloride emulsion boiled; No. 4, chloride emulsion unboiled; No. 5, iodide, bromide, and chloride. I am not quite certain about the proportions. No. 6—one part of iodide to eight of bromide—is colored quite as strongly as any chloride plate can be. No. 7 is one part of iodide to one part of bromide; No. 8, bromide by itself; No. 9, one part iodide, one chloride, and eighteen bromide; No. 10, unboiled iodide with no bromide; No. 11, boiled bromide. I simply wish to bring these experiments under the notice of the members of the society, so that they may not conclude hastily that, because they have got chloride in a plate, it blackens rapidly. It does, in fact, nothing of the kind, as iodide or bromide blackens quite as rapidly.—*Photographic News.*

PHOTO DEVELOPING DISH.

W. J. WILLIAMS describes in the *Photo News*, as follows, a developing dish by the use of which the plate can be raised from the solution without contact with the fingers: A B C is a piece of wire hinged to the dish at A B, and rising from



the dish in the form of a handle at C. By lifting the wire at C, the plate is of course raised from the solution, and can be examined at ease without touching it with the fingers. The dish should be of zinc or tin, and the wire of copper or galvanized iron.

GRINDING WHEAT.

AT a recent meeting of the Institution of Civil Engineers, London, Sir Frederick Bramwell, Vice-President, in the chair, three papers were read, the first,

"ON THE VARIOUS SYSTEMS OF GRINDING WHEAT, AND ON THE MACHINES USED IN CORN MILLS,"

By Mr. W. PROCTOR BAKER.

The author stated that it was impossible to discuss exhaustively in a short paper the different processes and all the various machines used in modern corn mills; but a general sketch of the conditions under which the trade was carried on in the United Kingdom, compared with those of competing countries, and a description of the systems in vogue and of the machines in use, might be attempted. Wheat, originally ground in a pestle and mortar, or between rollers and a hard stone tablet, in both cases by hand power, was by the Romans, at the time of the Christian era, ground by millstones, and a thousand years ago the millstone did not differ materially from that of the present day. The sifting of the meal, however, seemed to have been done by hand labor, and the machines by which flour was dressed were products of quite recent times.

The Exhibition of Mill Machinery, in 1881, directed attention to the revolution taking place in the art of milling. The Hungarians and Americans had been credited with the possession of processes which the millers of this country were thought to have been slow to adopt, and consequently it was supposed they were in danger of losing their trade. It appeared, however, that these processes were combinations of machinery of recent introduction, but still well known to British millers, and that they were not adapted to the manufacture, as it was obliged, by circumstances, to be conducted in this country. The flour to be obtained from any given description of wheat was not, as ordinarily supposed, all of one quality, which varied according to its position in the wheat kernel.

The methods in general use made one flour of average quality from the grain, which was of a description that met a ready sale. The Hungarians and Americans divided and sub-divided the qualities from one wheat, the former into as many as ten or twelve sorts, the latter into a smaller number; and as different markets required different qualities, they were able to find a market for the whole series of qualities, sending each to an appropriate market. But the home miller was obliged to make, for his own local demand, the particular quality which the district required, because the home market was his only market. As a rule, only one quality of flour being required in the district within reach of a mill, the home miller was debarred from using processes whose success depended on finding markets for several qualities, and especially on selling the very fine flours at high prices.

The system in general use up to about ten years ago was low grinding, by which it was sought, at one operation, to crush the kernel of the wheat into flour, and at the same time completely divide the flour from the bran. Lately, the tendency had been not to complete the grinding at one operation, but rather to proceed on a system known as "gradual reduction." The reason for the change of practice was, that in low grinding not only was the interior of the grain crushed into minute particles known as flour, but, at the same time, the bran being brittle, broke, or a portion of it was broken, into equally small particles, and these became inextricably mixed up with the flour and could not be separated from it.

The presence of these particles in the flour gave a dark color to bread made from it. A system based on the Hungarian procedure had come into use in order to avoid this disadvantage. It was sought, while dividing the bran from the interior of the grain, to break up the latter, not into flour, but into fragments of the size of a very small pin's head, known as "semolina," or "middlings." But in doing this, particles of bran were still broken up and mixed with the semolina. The semolina was, however, large enough to be subjected to a winnowing operation, performed by an appropriate machine called a "purifier;" this separated the branny particles, and left the "semolina" pure, being, in fact, small fragments of the wheat without mixture of bran. The fragments were crushed by roller mills or millstones to flour, and gave a pure flour free from specks. Not only, however, was it possible thus to separate the bran, but as the semolina varied in density according to its position in the wheat corn, and as that which was most dense gave better flour than the less dense, the semolina itself was graded in quality according to its specific gravity, and each grade being ground separately gave a different quality of flour. Thus, several different qualities of flour were obtained from the same wheat. To get semolina instead of flour, it was necessary to subject the wheat to a cracking rather than to a crushing action in grinding, and for this purpose the grinding had to be accomplished at repeated operations, hence the system was named "gradual reduction." Between it and "low grinding" there were several other systems, as "high grinding," "half-high grinding," and others, depending on the lesser or greater amount of crushing power used in the initial operation of grinding.

The wheat of commerce delivered to the miller contained all manner of seeds, dirt, stones, nails, and articles inappropriate for flour-making, which it was necessary carefully to remove. A considerable number of machines, performing different functions, had to be provided for the thorough cleansing of the wheat, removing all dust and polishing it, before it was ready to be ground. The grinding, which was formerly accomplished altogether by millstones, was now in some cases entirely, and in other cases at some stages, performed by roller-mills. The use of these was extending. The designs were various, but there were certain points which experience had shown must be common to all good roller-mills. It had been established that the best materials for the roller were chilled cast iron or porcelain. The former might be used for grinding wheat or semolina, the latter was fit for soft semolinas only. The chilled iron was hard enough and tough enough to bear the severe friction of wheat-grinding without material wear, a friction that porcelain would not stand; but on account of the slight porosity of the surface, porcelain was preferred by some for grinding soft semolina. As considerable pressure was used in grinding semolina, the rollers were apt to heat, and it was found that rollers of about fifteen inches in length were the longest that could be usefully employed, while other considerations fixed the diameter at about nine inches. Rollers for grinding semolina had smooth surfaces, and might run at equal or differential speed; rollers for grinding wheat were grooved or fluted, and ran always at differential speeds. Pressure was applied through the bearings in various ways, by levers, wedges, springs, or screws; but the design of Mechwart, of an anti-friction ring-pressure, afforded the means of applying heavier pressure than any other roller-mill. All other things being equal, the roller-mill which gave the operator the power of putting the greatest pressure on the material to be ground was the best. Another novelty was the centrifugal silk dressing machine, which consisted of a cylinder slowly revolving, through which the flour was driven by beaters running at a high speed inside it. This machine was almost a necessary accompaniment of the roller-mill, as the meal ground by rollers had a tendency to cake, and the beaters were needed to break up the cakes. But the most important machines of recent introduction were the "purifiers," which were used for the purpose of purifying and classifying the semolinas. These machines worked either on the principle of causing the semolina to pass through a series of passages, where it was exposed to currents of air, which first removed the bran, and then, as it were, weighed the semolina and divided it; or by centrifugal force the semolina was scattered in a shower, and divided in consequence of the heavy particles flying further than the light ones; or by an arrangement by which the semolina was made to traverse a long sieve, which had a rapid joggling or oscillating motion. In the latter case the motion caused the heavier particles to sink to the surface of the sieve, and the lighter ones to float on the heavier ones. A pressure of air was kept up under the sieve just sufficient to prevent the light particles from falling through the meshes, while the heavier particles which were heavy enough to overcome the air pressure, fell through the sieve and were collected at the bottom of the machine. An exhaust above the sieve carried away the lightest particles, and all but the lightest and the heaviest passed away into a receptacle at the lower end of the sieve. The purifier was of more importance in the modern processes than the roller-mill, for the work of the latter might be done by the millstone, while without the purifier neither the millstone nor the roller-mill could make pure or the finest flour. As the taste for whiter bread appeared to be on the increase, an extension of the high-grinding systems might be expected.

The second paper read was on

"MODERN FLOUR MILLING IN ENGLAND,"

By Mr. HENRY SIMON.

The importance of the flour-milling industry of the United Kingdom was first noticed, as much as £2,000,000 per annum being turned over in a single milling establishment in London. Much flour was also imported from Hungary and the United States, especially from the latter country. The quantity of wheat ground in England in one year was more than 25,000,000 quarters, and for the whole of Europe the daily expenditure for cereals to be ground was about £1,500,000. It was stated that flour produced by roller mills in England was worth 2s. 6d. to 5s. more per quarter than that ground by stones, the wheat being of the same quality. The systems of low-grinding and high-grinding were then referred to. The former, until recently, was the general practice in this country, the latter was the rule in Hungary and in America. The difference between the two systems was explained. It was stated that the action of low-grinding was violent, producing heat that spoiled the flour in color and in baking and keeping quality, and that the damping of wheat in low-grinding was detrimental to the quality of the flour. High-grinding was carried on without damping or steaming; the bran and germ were taken out, and the flour kept well. The fundamental principle of high-grinding was gradual reduction of the grain, the branny particles being carefully separated before each succeeding step in the manufacture, for which purpose five or six breaks were sufficient. Millstones were being gradually dispensed with; all improvements now in progress in this country were in the direction of high-grinding with roller-mills. Low-grinding with roller-mills produced less flour and of inferior quality. Whole-meal flour was the product of the lowest step of low-grinding; the highest Hungarian brands came from the highest grinding, the equal of which was now being produced in this country. The evolution of roller mills was then detailed. Their first practical application was in Budapest in 1839. The flour ground by rollers moving at equal speed was caked or flaked; differential speed was important, and the purification of the products before proceeding with further reduction. The first rollers, although adjustable in distance, were kept rigidly in place; the advantage of Wegmann's improvement was the fixing of the journals of the rolls in levers, acted upon by weights or springs. Wegmann had also introduced porcelain rollers, but these were not so durable as chilled iron rollers, and were not applicable for granulating grain. The different ways of driving roller-mills by straps or gearing were mentioned, and serious drawbacks in the former pointed out. The various methods of fluting the rollers were described; sharp-edged grooves had proved the best, with from ten to thirty grooves in the space of an inch. Vertical grooves, and grooves parallel to the axis, had been used. Reference was then made to Carr's disintegrator, and to Nagel and Kaemp's system. The author next pointed out the advantages of roller-mills over stones, among them being the fact that the former flattened the bran and germ, which could then be easily dressed out, and did not attack them. The expense of repairing the rollers was small as compared with dressing the stones; the product of flour was as great, there was less danger of explosions, less space was occupied by roller-mills, and much less power was required. A statement was given of the power required in three of the mills erected by the author. Roller-mills were introduced into England by Buchholz, in 1862, but the results were unsatisfactory. The Hungarian process was introduced by Oexle, in 1868; later an impetus was given to roller milling by Wegmann's improvement of porcelain rollers, and "middlings," formerly a drug in the market, now became valuable. The system advocated by the author was introduced on an experimental scale in 1877, and, since the Kilburn Exhibition of 1879, had met with general acceptance. The fundamental principles of this process were—first, gradual reduction of the wheat by fluted rollers with sharp corrugations; secondly, cleaning of the bran by fine fluted rollers, all with differential speed; thirdly, gradual reduction of the semolina, principally by smooth rollers, or in some cases by fine fluted rollers. A description of machinery used in the author's system was given. This included (1) Daverio's roller-mill, the principal feature of which was cross-fed channels and effectual friction relief; also three rollers gave the same work as four rollers in other mills. (2) Dressing machinery; it was stated that the ordinary silk reel was now displaced by the centrifugal reel; the centrifugals recommended by the author were described, and the different classes of centrifugal reels made. (3) Purifying machinery. Finally the paper contained a description of the modern high grinding process by roller-mills. This was divided into three main operations: granulation, or the separation of the outer husk of the grain; purification of the product thus obtained from bran; and the gradual reduction of the purified semolina into flour. These different operations were fully described, illustrated, and explained.

"ROLLER-MILLS AND MILLING AS PRACTICED AT BUDAPEST."

By Mr. W. B. HARDING.

In the early years of the present century it had been recognized that, in order to obtain pure wheaten flour free from particles of bran, the old custom of grinding between stones must be superseded, at least as regards its constituting a complete process. The outcome of various experiments was the roller-mill, probably first brought into practical shape and used in Switzerland about the year 1820. In 1839 was established, from the designs of Mr. Fehr, a Swiss engineer, the "Josef Walzmühle," the first in Hungary to adopt the new system. The installation comprised thirty-six roller-mills, with which it was originally proposed to accomplish the whole work of grinding, but subsequently eight pairs of

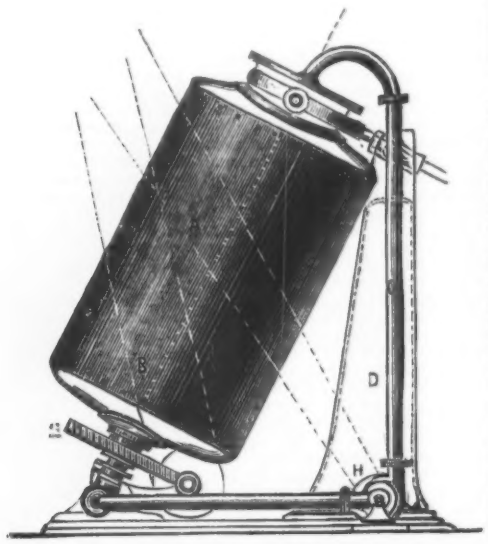
stones were added to effect the finer reductions. This mill afterward passed into the hands of a company, and became known as the "Pester Walzmühle," and its powers of production were increased by the addition of sixty-four roller-mills, besides several pairs of stones. During the last thirty years, thirteen other large mills on the same principle had been erected in Budapest; and the result of nearly fifty years' experience was to define clearly the functions and position of the roller-mill as the agent most suited for the preliminary process of granulating, requisite in the production of high-grade flour. For the subsequent reduction of the middlings produced by the rollers, nothing had been found superior to the old-fashioned stones; a modern first-class mill in Hungary, therefore, contained each class of machine as the necessary complement of the other.

The system of milling adopted in Budapest had for its object to obtain, from a given quantity of grain, the largest amount of fine white flour, and the commercial success which had attended the costly and laborious efforts in this direction, might be taken as a proof that the end justified the means. As a broad principle, the manipulations required in high grinding remained the same under all circumstances, although local conditions and the nature of the wheat might vary the details of the operation. The process necessitated five or six times "shroten" (*i. e.*, bruising or granulating) between fluted rollers, and the passing of the produce from each break through a system of sorting and dressing machines. Further, from twice to four times "auflösing" (*i. e.*, separating small portions of bran adhering to the fine middlings), between rollers either quite smooth or very finely fluted, the produce being carefully sorted and dressed as before after each operation. Lastly, the passing of the purified middlings and meal between stones, and the final dressing. The whole manipulation was arranged so as to require a minimum of manual labor, and the transport of the various products in the required direction was arranged automatically.

The method of procedure in a large mill was described in detail, from the time the wheat, thoroughly cleaned, was delivered to the first roller-mill, to the sacking of the refined flour, by which time it had undergone eighteen distinct operations, performed at different stages of a continuous journey through the mill, besides being concerned in various subsidiary processes affecting the treatment of the by-products.

BOILING KEIR FOR YARN AND CLOTH.

THE keirs generally used for boiling yarn or cloth intended to be bleached are stationary, and in the modern ones the water or liquor employed is made to circulate by means of an elevator or injector. In Germany, however, a revolving keir, for circulation of the liquor, has been adopted, the idea having evidently been borrowed from the revolving boilers used by papermakers. Our illustration shows the main features of this arrangement. A is the boiler or keir, made of wrought iron, which revolves round its axis, inclined at an angle of about 40 degrees. Its upper end runs in bearings held by an upright stand, D, while the lower end, which terminates in a pipe, runs in a hollow footstep. A wheel and gearing, E, driven by a strap, give the keir its rotary motion. The pipe at the bottom is in connection with a horizontal one, going up to a centrifugal pump, H, also driven by a strap, and from which another pipe ascends and runs up to the lid of the keir. Thus, while one strap causes the keir to rotate and to turn about its contents, the other strap, by giving motion to the pump, will cause the liquor to circulate constantly from the bottom to the top of the keir. There can be no doubt about the advantage of this circulation, and when the material to be washed is in detached parts, as, for instance, well-tied hanks, the constant turning may assist the washing, but we fear that cloth may soon get entangled, and may suffer in consequence, unless there is a provision made in the keir to prevent this, of which, however, the foreign patent says nothing.—*Textile Manufacturer.*



BOILING KEIR FOR YARN AND CLOTH.

ARTIFICIAL INDIGO.

THE preparation of indigo is still too costly, and its use in printing is attended with such inconveniences that the attempts at its production have been for the present discontinued in the two great establishments which had entered upon the undertaking. Among recent improvements have been the replacement of the oil of bitter almonds and acetic anhydride by benzyline bromide or chloride and anhydrous sodium acetate. Cinnamic acid cannot be quantitatively transformed into ortho-nitro-cinnamic acid, which alone is capable of yielding indigo. A quantity of the para-acid is formed at the same time. Indoine is a new compound obtained by M. Baeyer from ortho-nitro-phenyl-propionic acid. It presents certain analogies with indigo, but is yet distinct.

IRON PYRITES: ITS FORMATION AND DECOMPOSITION.

By PROF. F. SANDBERGER, Ph.D.

THERE is no state of rest in the mineral kingdom any more than in the organic creation. Both on the surface of the earth, and deep within it, old combinations of the mineral elements are breaking up, and new ones forming. It has long been known that without this continual decomposition of the mineral substances on the surface of the earth there could be no plant life, and as a necessary consequence animal life could not exist. A number of substances which are indispensable for the most important functions of the vegetable kingdom, are found in the foliage, the wood, and the fruit, such as lime, alkali, silica, phosphorus, and sulphur. They can be obtained only from the soil, and are taken up from decomposing minerals and assimilated by the vegetable organisms through very complicate processes. From the earliest times human necessity has taught us to accomplish this decomposition artificially. For this purpose the soil is broken up to a certain depth by the plow, so as to continually expose new strata to the action of the atmosphere, *i. e.*, to permit of certain substances being converted into a soluble form, so that they can be taken up by the roots of the plants. This soil is not homogeneous, but contains, as a rule, remnants of different minerals, and must contain them if it is able to furnish plants with all the food required for their vital processes. Since every single mineral produces different products of decomposition according to its chemical relations toward water that contains air or carbonic acid, the soil and the liquids that penetrate it are the end product of a whole series, and not of a single decomposing process.

Every other mixture of minerals acts like the soil, and by its decomposition produces a whole series of new products which seem to be mixed together promiscuously. To comprehend the signification of the single factors of this mixture, it is necessary to investigate how each single original constituent of the mixture decomposes, and what new substances it contributes to the final product. Such investigations lead to one of the most interesting portions of geology, to which as yet but little attention has been directed by the public, although it certainly deserves attention.

It is not my intention here to describe the formation and decomposition of a large number of minerals, but rather to follow out one which is widely disseminated, and hence is of importance for practical life. Before entering into particulars, it may be in place to say a few words as to how we can most certainly prove from which old mineral the new one was formed. It is evident that in this respect those cases are most important in which the decomposition takes place so gradually that the new body is obtained in the crystalline form, more or less perfectly preserved, of the original mineral, or what is called in mineralogy a pseudomorph, is formed. For example, *Argentite* (sulphide of silver Ag_2S) is in the form of *Pyrargyrite* ($3\,Ag_2S.Sb_2S_3$) or dark red silver ore. In this case there is no doubt that the former is made from the latter, which has lost its sulphide of antimony, *i. e.*, has given it up to a liquid in which the antimony compound was soluble, and sulphide of silver was not. But we know from chemistry that only the sulphides, such as sulphide of potassium, sodium, ammonium, barium, or calcium, are able to dissolve out the sulphide of antimony in such a dilute solution and secluded from the air, and to produce the pseudomorph in question artificially in a not very long time. If we find hydrated silicate of alumina, the white, earthy kaoline, in the same shape as a potash feldspar, or other feldspar, which is an anhydrous double compound of alkaline silicate with silicate of alumina, we have a right to infer that kaoline must have been formed from a feldspar through the loss of the alkaline silicate. In all cases where we have pseudomorphs, we have a very definite starting point for determining the original body from which they are formed, although the formation in very many cases depends upon complicated processes, such as the mutual decomposition of natural substances; not like the very simple conversion of red silver ore into argentite, and of potash feldspar into kaoline. One of the most instructive examples of mineral changes is undoubtedly that of iron pyrites.

Pyrite, or iron pyrites, when pure, are bisulphide of iron (FeS_2), with 46·08 per cent. of iron, and 53·92 per cent. of sulphur. It crystallizes in forms belonging to the regular or isometric system; the cube, octahedra, and pentagonal dodecahedra being most frequently observed. Of the same composition, but crystallizing in the rhombic system (that is, dimorphous) is the markasite, which is much less common. Since its formation and decomposition scarcely differ from that of pyrites, any special description of it would be superfluous.

Iron pyrites have a brass yellow color, very brilliant metallic luster, a high specific gravity (5), and a hardness almost equal to that of quartz, giving sparks when struck with steel, and formerly used in starting fire. It is not magnetic, and is not attacked by hydrochloric acid, but only by hot nitric acid. Besides sulphur and iron it not infrequently contains other substances which do not change its crystalline form, such as arsenic (up to 4 per cent.), and selenium, replacing the sulphur, or gold (not over 0·02 per cent.), platinum (0·05 per cent.), silver (0·10 per cent.), copper (up to 5 per cent., Huelva), thallium (to 1 per cent.), or cobalt, nickel, and manganese replacing part of the iron.

DECOMPOSITION BY HEAT.

If heated to redness in a closed vessel, it is decomposed and sulphur is given off, which is either used for making sulphuric acid, or comes into commerce as sulphur. The residue is a lower sulphide (Fe_nS_n), a black, porous, and strongly magnetic substance which resembles the natural magnetic pyrites, and, like it, dissolves readily in hydrochloric acid with the evolution of sulphydric acid. In the great chemical industries, however, as yet no process is known whereby all the sulphur expelled by heat can be obtained, but only 13 to 14 per cent., because if heated more strongly the clay retorts would be destroyed. Arsenic and selenium, if present, sublime with the sulphur, which is thereby rendered unfit for many purposes, such as fumigating casks and barrels, as the very poisonous vapors of arsenious and selenious acid are formed when it is burned. It must, therefore, be redistilled.

When strongly heated in the air, pyrites are decomposed into sulphurous acid and basic ferric sulphate. The residue can be used for making green vitriol, and then for oil of vitriol, or anhydrous sulphuric acid, and polishing rouge, *caput mortuum*. In it remain all those substances which in part replaced the iron, such as copper, silver, gold, platinum, thallium, and manganese, and can be prepared from it if present in sufficient quantity. This sulphuric acid residue is imported by the shipload into Germany from the province of Huelva, in Spain, and worked over to obtain its copper and silver, and on a still larger scale at Newcastle-on-Tyne, England. The total amount of copper produced in Central Europe from these pyrites residues is estimated at 250,000 cwt. The amount of silver is much less, but still enough to pay. When there is considerable gold, as in the pyrites of Alais (Department of the Gard), this, too, is won. The greatest part of the sulphuric acid which plays such an important part in chemical industry is made from iron pyrites. In recent times, indeed, copper pyrites and zinc-blende are also employed for the same purpose.

FORMATION OF IRON PYRITES.

It can be said that iron pyrites are formed wherever ferrous sulphate, or any other soluble sulphates, like gypsum and Glauber's salt, and iron salts, particularly the carbonate, come in contact with decomposing organic matter. This last-named substance possesses a power not equaled by any other natural body of abstracting oxygen from other substances at ordinary temperatures, *e. g.*, of reducing sulphates to sulphides. In this way monosulphides are first formed, as further conditions must be fulfilled to produce the bisulphides. The foul liquids from the kitchen and sinks contain, according to the state of decomposition, sulphates of potash, soda, lime, or ammonia and organic substances, or the latter are already destroyed and have converted these salts into sulphides of potassium, sodium, calcium, or ammonium. These substances at once attack the iron in the gutters or the bottom of the sewers and ditches, and deposit there an intensely black slime. This is a hydrated protosulphide of iron, like that precipitated from a solution of iron by sulphide of ammonium in chemical analysis, as shown by Chevreul (*Compt. Rend.* xlii., p. 128). Not only does this take place in the waste from inhabited places, but sulphide of iron is also being produced in every peat-bog, as well as in the slime from ponds and rivers, and on a very large scale in that of the sea, wherever iron salts and sulphates are present. The production of sulphite of iron is, therefore, going on almost uninterruptedly over the whole earth, as the necessary conditions are rarely wanting anywhere.

DECOMPOSITION OF PYRITES.

Wherever this protosulphide comes into contact with the atmosphere, it rapidly oxidizes again, and it is therefore not often found in a hard, stone like mass. Yet I have seen one interesting case, where it had kept for years in a dry place. In 1857, during ebb tide at Ostend, I discovered a new formation of that sort. The iron piles driven in there are surrounded at the base with a blackish mass 9 centimeters thick (nearly 4 inches), in which were well preserved purple shells of the edible mussel, so common there (*Mytilus edulis*). I took some pieces with me, and treated them with hydrochloric acid, which immediately evolved large quantities of sulphureted hydrogen and carbonic acid, and the mass crumbled to grains of sand. The decomposing mussels, which as usual had attached themselves in large numbers to the piles, had reduced the gypsum in the sea water to sulphide of calcium, and this had acted upon the iron and converted it into protosulphide of iron, while the calcium thus liberated had taken up the carbonic acid formed by oxidation of the organic matter, and formed carbonate of lime, which had cemented together the grains of sand from the bottom of the sea to a strong mass. It was only after several years that the piece was decomposed throughout, and fell to pieces. Undoubtedly, the same process takes place under the same conditions in every sea where the sand contains iron.

The sulphide of iron is less easily attacked when it has taken up more sulphur, and becomes a bisulphide of iron or pyrite. This takes place when it remains in contact with a solution of liver of sulphur, an alkaline sulphide, from which it is able to abstract more sulphur. This process is very clearly shown in nature by certain pseudomorphs. Such are the large, six-sided plates from the ore veins at Freiberg and Stranitza, which as a rule consist of an aggregate of small pyrite crystals, but sometimes consist in part of the original hexagonal crystals of magnetic pyrite. It is therefore probable that in nature at first a mono, or eight-ninths sulphide of iron is formed, and this is afterwards converted by the alkaline sulphides into a bisulphide. This explains the frequent occurrence of gold in iron pyrites, for sulphide of gold is soluble in the alkaline sulphides, and is added to the protosulphide of iron in such a solution.

There are some very striking but well authenticated cases, within historic times, of dead organic bodies being converted directly into pyrites. Thus, a mouse drowned in a vessel containing a solution of green vitriol, in Bakewell's laboratory, was changed to pyrites; pyrites form in hollow trunks of trees, in mineral springs, on the roots of rushes, etc. Still more instructive are the magnificent, glittering layers of pyrites upon bowlders, and rubble and rough masses like a cement of sand, such as are dug out of marshes by filled-up mineral springs, that contain sulphates and iron salts, like those at Roisdorf, near Bonn, and at Memlos, near Fulda. So, too, the pyritical lumps that I dug up in the marshy soil at the Wurzburg pile-house, at a depth of 2½ meters, and which inclosed grains of sand, pieces of bones, and fragments of oak. The examples cited, which might be multiplied still more, will suffice to justify the above assertions that iron pyrites are at present still being formed uninterruptedly, and in large quantities, on the earth's surface, and must have been formed in the same way in times past.

There are, indeed, no deposits of stone coal or brown coal that do not contain a quantity of pyrites in some of the stratifications, and in many of them they are so abundant that they are worked for the pyrites instead of for the coal, as at Kladno, in Bohemia. The bisulphide of iron is found not only in fossil coal of all ages, but in all rocks impregnated with organic substances, whether these are in the earlier or later stages of decomposition, *i. e.*, as ulmic bodies, bitumen, pit coal, or anthracite. They are generally most abundant in certain clay-shales and marl shales. This occurrence of pyrites is again very characteristic. Wherever there are large fossil organisms like conchylia, ammonites, orthoceratites, or stems of plants in these strata, the pyrites are concentrated in and around them. Sometimes they are in masses as large as a fist or a man's head. There are no more striking proofs that in early geologic times bisulphide of iron was formed in great quantities by decomposing animal and vegetable substances from solutions of the sulphates, just as it is to-day everywhere being formed, and not only in the rocks already mentioned, but along with other metallic sulphides on ore veins and gangue. The tremendous beds of pyrites at Undal and other places in Norway are accompanied by a black clay shale, and in some places contain as much as 2½ per cent. of coal, which

gives it a black color. The same is true of those from Meggen, in Westphalia. In the Black Forest and the Rhenish Mountains there are scarcely any pyrites which do not rest upon rocks that are impregnated with anthracite or graphite. Here, then, the reducing substance was present in excess, and was not all consumed, as was the case in other places, where it left no residue in the pyrites to prove that it had been there.

But then the mineral is formed at the present time in other ways, although in far smaller quantity. This must also be mentioned here to correct the popular but false idea that the same mineral must always be formed in the same manner in nature.

Iron pyrites are formed on volcanoes, not in the lavas, but only as a product of decomposition of the oxygen compounds of iron (magnetic oxide of iron, silicate of iron), which are abundant in volcanic rocks, by the action of sulphureted hydrogen, which is so common in many volcanic regions, especially in Iceland and Lower Italy. In 1847, Bunsen showed that by the continued action of such sulphureted hydrogen emanations the volcanic tufa of Iceland is being converted into a clay in which are crystals of pyrites and gypsum. The alumina and the silica of the rocks are not attacked by the sulphureted hydrogen, and hence form an argillaceous residue free from color. The iron gives its oxygen to the hydrogen of the sulphureted hydrogen, taking its sulphur in exchange. The lime and alkalies are next converted into sulphides, which rapidly oxidize in the air. The sulphide of calcium splits up into sulphur and sulphate of lime (gypsum), which owing to its slight solubility crystallizes out, while the alkaline sulphides form soluble sulphates, that are washed away by the rain water. Hot solutions of alkaline sulphides, such as are found in California and Nevada, have the same action as gaseous sulphureted hydrogen. They, too, deposit pyrites in the volcanic tufas which they flow through, and the like occurs on a small scale at the springs of *Chaudes Aigues* at Cantal, and at Aix-la-Chapelle.

It will be seen that the very frequent formation of pyrites all over the earth is due, with the exception of those just mentioned as of volcanic origin, to a grand reducing process on a large scale, which results in a concentration of the sulphur out of the soluble sulphates, and in a less degree to a concentration of the iron. At the same time, other elements which are present along with the sulphur, but in much smaller quantities, combine with the iron, and with this any gold, platinum, silver, thallium, copper, cobalt, and nickel present are also precipitated.

NEW COMPOUNDS.

If we consider now what new compounds are formed from its decomposition by oxygen, we will run foul of a series of very remarkable facts.

The kind of decomposition that pyrites undergo from the action of the atmospheric oxygen, varies according as there is an excess of oxygen or only a limited supply, and in some varieties, the fine granular sort, is rapid, while others fall to pieces gradually. With a limited access of air, the pyrites become slowly covered with an efflorescence of green vitriol ($FeSO_4+7H_2O$), in the production of which all the iron is consumed, but only one equivalent of sulphur. The second equivalent of sulphur separates as native sulphur, and remains between the crystals of vitriol in yellow flakes. On extracting this weathered and crumbling mass with water, which dissolves the ferrous sulphate, the yellow flakes can be distinctly recognized and proven to be sulphur, either directly by melting and burning, or by dissolving in alkali, which then precipitates metallic solutions. Sometimes this second equivalent of sulphur is protected from oxidation, and is found in between the second product resulting from the decomposition of the green vitriol, as very beautifully seen in the pseudomorphs of brown hematite after pyrites, at Rippoldsau, in the Black Forest, and in those from the Ural, where free gold sometimes is found with the sulphur in pseudomorphic geodes and druses.

When the pyrites are oxidized with free access of air, the second equivalent of sulphur is also converted into sulphuric acid. This gives a strongly acid reaction to the sulphate of iron solution, and when in contact with minerals that can be attacked by it, produce a very energetic reaction that results in the production of a great variety of secondary minerals to be described subsequently.

The formation of green vitriol is always attended with a large increase in volume corresponding to the oxygen and water absorbed. This causes the mass of pyrites and the rock it may be embedded in to swell up, become porous, and crumble.

The production of green vitriol is going on in a large way in the pyrites deposits, which are from 100 to 300 feet thick, at Rammelsberg, near Goslar, in the Hartz Mountains, and at Rio Tinto, in Spain. Besides the green vitriol, and the lemon yellow basic sulphate of iron formed from it by oxidation, there are at the so-called "Old Man" in Rammelsberg, sulphate of copper, sulphate of zinc, and other sulphates formed by the oxidation of other metallic sulphides that accompany the pyrites. These are separated as far as possible from each other, and then worked up. At Rio Tinto acid water flows from the abandoned Roman mines at Teil, in such quantities that it blacks everything, and the precipitated hydrated oxide of iron cements the pebbles into a conglomerate. The copper in it is precipitated by old iron, and obtained in the form of cement copper. It is estimated that 75,000 tons of copper have been washed out of this old mine since the fifth century, and carried into the sea. Since the iron pyrites do not contain over 5 per cent. of copper, of course the quantity of iron is still greater, and it would be remarkable if iron sandstone were not formed in large quantities continually at the mouth of the river.

The formation of vitriols in mines has other consequences, too. In proportion as oxygen is taken from the air to oxidize the sulphides, the percentage of nitrogen in the air increases, and if the ventilation of the mine is bad, it may increase to such an extent that the workmen not infrequently die of suffocation. Such cases also occur in all coal veins which are rich in pyrites and the necessary precautions are neglected.

Not less fraught with danger to the mine are the physical effects of this oxidation, particularly the considerable increase of temperature that accompanies it. In stone coal and brown coal mines, if the slack and small pieces of gangue, which are full of finely divided pyrites, are not carefully removed but left in porous heaps in the galleries where the air has free access to it, oxidation begins; slower, indeed, than with the monosulphide of iron, but gradually increasing until it glows, and if the draughts of air are strong enough, it sets fire to the heap of slack. This would gradually spread, if the access of air cannot be cut off, until the whole mine is on fire. The fire in the Fanny Mine, in Upper Silesia, at Planitz, near Zwickau, and the burning mountain at Duttweiler, near Saarbruck, are the best known mine fires in Germany. But in France and other countries many mines have suffered from fire at different times. At Teplitz and Carlsbad there are evidences of such fires.

Everywhere, the shale that incloses the vein, at the spot nearest the fire, is converted into a pearly-gray substance resembling porcelain, and called porcelain jasper. Sometimes it is burnt red, and hard. In the cooler spot the crevices are filled with sulphur, which has distilled directly from the pyrites and alum, the formation of which we shall describe presently, and salammoniac formed at the expense of the nitrogen in the coal. To utilize the heat greenhouses were put up at several places, as at Zwickau; and tropical plants, especially pine apples, cultivated on a large scale.

If the deposit of pyrites is in quartzose rock that cannot be acted upon by free sulphuric acid, mine water, having a strongly acid reaction, will flow out, destroying any vegetation that attempts to grow along its banks. Such waters contain 1 part, 2·2 parts, and even 5¼ parts of free sulphuric acid in 10,000 parts of water. Such waters are found at Ronnely, in Sweden, Civillina, near Venice, and in Rockbridge Co., Virginia. No higher percentage is found, except in waters of the Solfataras, which are formed in lower Italy, Mexico, South America, and Java, by the condensation of sulphurous acid and vapor of water.

In most cases, the sulphuric acid formed by the weathering of pyrites has an opportunity to unite with bases at once, and to form various new minerals according to the kind of rock the pyrites were in. The most common ones are sulphate of alumina and gypsum. Since potash is seldom wanting in the shales where iron pyrites are found, alum is formed, and is seen as a white, mealy, or capillary efflorescence. As long as no cheaper materials were known from which to make this substance, which is so indispensable in many technical operations, alum was obtained in very many places from just such rocks. Up to the present time they retain the name of alum slates, and occur in all geological formations, for example in the transition rocks of Sweden, Saxony, and Thuringia; in the clay formation over the carboniferous in Thuringia and Wurtemberg; in the brown-coal clays of the lower Rhine and Lausitz, etc. At present they are not worked, except under exceptionally favorable circumstances, for alum can be made far cheaper and purer from alum-stone, and from the residues left in making soda from cryolite, without the necessity of removing the troublesome iron salts which are formed in the alum slates with the sulphate of alumina. Where such rocks have been decomposed on a large scale, they break up in little splinters, which are continually breaking off. Streams that wash away the slime from these rocks contain neither fishes nor plants, not even shell-fish, because the dissolved salts are inimical to vegetable and animal life. Before such alum shales can be worked they must first be roasted, to oxidize the fresh or only partially decomposed pyrites which they contain. This is finally completed by letting them lie exposed to the air for a year. Then they are leached out, and clarified, so as to separate the iron as basic salts. An equivalent quantity of carbonate of potash is now added, and pure alum is obtained.

If the rocks that contain the pyrites are chiefly carbonate of lime, like limestone, quite another phenomenon takes place. The liberated sulphuric acid first attacks the carbonate of lime, and converts it into hydrated sulphate of lime (gypsum), liberating an equivalent quantity of carbonic acid, while the sulphate of iron decomposes the carbonate of lime, forming sulphate of lime and carbonate of iron ($CaCO_3+FeSO_4=CaSO_4+FeCO_3$). Protocarbonate of iron, known in mineralogy as siderite, is readily oxidized still higher, and with access of air and water the carbonic acid escapes, and the hydrated sesquioxide, called brown hematite, is formed, $2(FeCO_3)+O=Fe_2O_3+H_2O+2CO_2$. Thus the pyrites is at last changed to brown hematite. Yet not infrequently the crystals preserve their form perfectly, but of course the interior is greatly changed, having become porous and crumbly. This metamorphosis may attack a whole bed or deposit of pyrites, and extend to a great depth. At Huelva, it reaches down over 300 feet. The miners rightly call these deposits of porous hematite, that consist of pyrites down below, iron hats, and prize them highly. The old miner's saying, that "No vein is so good as an iron hat," is founded on this, for in the hematite are found concentrated all those metals like gold, silver, and platinum, which were mixed with the pyrites in small quantity, but which cannot oxidize any farther, and when separated from their sulphur compounds, appear native or free. The richness of these "iron hats," or pacos, the Spanish-Americans call them, is frequently extraordinary, and increases rapidly with the depth. All the beds and veins of gold and hematite in Australia, California, and South America have proven without exception that the amount of gold decreases rapidly as we descend, when this oxidized zone is passed and we come to the pyrites below. It is true that this also contains gold, but only in very small amount, and scattered through a very large quantity of iron and sulphur. No less definite are the statements regarding the decrease in the yield of silver, in all cases where the shaft extends from one of these iron hats down to the original pyrites.

It will be seen that many wonderful geological phenomena are connected with the formation and destruction of iron pyrites, as well as many products of industrial importance.

Humboldt, May, 1882.

THE AMOUNT OF OIL REMAINING IN PENNSYLVANIA AND NEW YORK.*

By HENRY E. WRIGLEY, C.E., Phila

THE BOUNDARIES OF THE OIL REGION.

THE boundaries in the oil region of Pennsylvania and New York, as determined by the drill, embrace a much larger extent of territory than is generally supposed, being nearly 200 miles in length from north to south, with an average width of 25 miles, covering an area, within somewhat irregular lines, of about 4,250 miles.

After twenty years of development we find these lines practically the same as those laid down by McClure in his geological map of the United States, published in 1817, and denominated and colored by him as the "line of salt," which was found in quantity long before petroleum.

The eastern line of the entire oil region lies in a northeast and southwest direction, parallel to and some distance west of the Allegheny Mountains; the south line is substantially one drawn between the southwest corner of Butler County and the town of Kittanning in Armstrong County; the west line passes up through Butler County, cutting off a small corner of Mercer, west of the towns of Franklin, Titusville, and Warren, into New York State, where it rounds off the end of this long strip in the counties of Allegheny and Cattaraugus, and joins the eastern line, near Olean, New York, just north of the city of Bradford. (See map.)

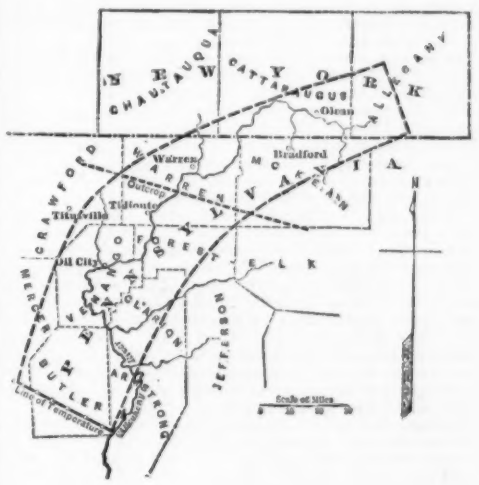
The eastern line, starting from Kittanning, passes through the northeast corner of Clarion County, the southeast corner of Warren, cutting Forest County through the center, and reaching the before-mentioned extreme northeastern developments near Olean. These lines have been taken broadly to include all territory that could ever possibly come into the question as oil producing.

These lines having been proved by the drill may be considered final. But there are also structural reasons for their existence. The south line is final because the oil-gathering sponge-rock on the line is found at such a depth, owing to the dip of the strata from the northwest, that the known temperature of the earth at that depth precludes the existence of hydrocarbons in any other than a gaseous form. The string of gas wells from Leechburg to South Butler County are brilliant and permanent witnesses to this fact.

The whole of this section of the States was at one time a level plain, the Allegheny Mountains being only waves of upheaval; these waves dying out as they went more and more faintly toward the Ohio line. The vertical fissures left in the strata by these waves of upheaval allowed the gas to come up from the buried shale 20,000 feet below, and condense in the pebble rocks under a solid cap or cover of unbroken rock 1,500 feet thick, where the drill tapped it in the form of oil. But where the rolls of the strata were so great that the fissures extended all the way to the surface, the gas came to the surface, too, and went off in the air as fast as it was made.

The eastern limit is the line where all the fissures of the anticlinals and synclinals have come to the surface, and a very little research will satisfy one as to the certainty and finality of this line.

The reason for the west line is just the opposite; the waves all died out and there were no fissures at all, so the gas could not come up. This same reason holds good on the north line all the way round to Olean, with this exception, that on the north line the fissures do exist at a greater and greater depth as we go northward; and we can reach them by drill and torpedo if we go deep enough, provided we never exceed the safe depth for temperature of 2,200 to 2,250 feet. We may safely assume that at a red-hot depth under the whole country lies the vast bed of the Huron coal shales, and the question is only one of distillation and outlet; of a conduit to some



natural condenser with a strong cover near enough to the surface of the earth to be above the line of temperature, so that we can tap it with the drill. No account is taken of the occurrences of oil from the upper light shales in the shallow wells at Mecca, Ottin, and elsewhere west of this western line, as they are totally unimportant factors in the general problem.

GEOLOGY OF THE OIL REGION.

Assuming the general surface of the country in Western Pennsylvania to be level, a board with its edges due north and south, east and west, tilted up slightly at the upper left-hand corner (representing the city of Erie), will give the general idea of the dip of the strata throughout this section. It will show two dips, one to the east, the other to the south; and, as the surface is level, these strata come successively to the surface as we go northward and westward. The oil sands of Butler County, for instance, if projected into the air on the line of their dip, would be 1,000 feet above the level of Lake Erie; so, too, the same third oil sand that we find at Tideoute, at a depth of 100 feet on the river bank, we find at 1,800 feet in Butler County. The oil sands practically end and crop out all across the oil section on the line shown above Tideoute.

Now there are four conditions necessary to the production of oil in quantity:

1st. The oil shale, which exists under the entire region, and far outside of it at a red-hot depth in the earth.

2d. Such vertical fissures, caused by upheavals in this secondary strata, as will allow the gas generated by the heat of the earth from these carbonaceous shales to escape upward to a point within, say, 2,000 feet of the surface.

3d. Between this point, and within, say, 100 feet of the surface, a cooler reservoir, either of coarse pebble rock or an aggregation of small fissures to receive the gas and condense it, either with or without pressure, into oil.

4th. Over this reservoir there must be a solid cap or cover of rock to confine the products of distillation.

In the entire region south of Tideoute the third or oil sand is traced readily by the record of the wells, and the known dip of the rock of about 20 feet to the mile, the level of the wells, if on a hill, being first taken from some known point.

In the entire region north of Tideoute the reservoirs are simply crevices and have no reference to sands, but the operator, carrying his experience of oil sand with him from below, drills his well down to a certain close gray sandrock as a guide. It is simply because he finds that the general horizon of the termination of the vertical fissures at the

* Transactions of American Institute of Mining Engineers.

upper end occurs in this particular line of strata. The gentleness of the waves of strata at this point, and the insignificance of the dip, account for the general regularity of the sandrock. But great perplexity is often caused by its occasional irregularity.

This entire long oil section of 4,250 miles may, therefore, be divided into two areas of pebble-rock and fissure territory respectively, with the dividing line of the outcrop of the pebble-rock a little above Tideoute. The oil region may be defined as that portion of Western Pennsylvania and New York which, within the boundaries here defined, possesses all the four requisites mentioned for the production of oil in quantity. On the east there is no cover; on the west it is all cover and no crevices within reach of a proper depth of temperature; and on the south the reservoirs are all below the line of temperature.*

THE PRODUCTION OF OIL.

Until January 1, 1875, the known area of oil territory was 3,115 square miles. This embraced all that part of the oil section described as pebble-rock territory lying south of Tideoute, with but trifling exceptions outside. Up to that time but 39½ square miles, or about 25,000 acres, of this area had been found to be actual producing territory by the sinking of nearly 11,000 wells.

During the next three years the discovery of fresh fields became more difficult, and as the average life of a well does not exceed two and a-half years, the price of gas steadily increased. This stimulated search to such an extent that before 1879 over 15,000 more wells were put down in all directions, resulting not only in the discovery of 11 more square miles of territory, but in condemning a vast portion of the outside field.

In 1879 Bradford had attained such proportions that its large product thrown on the market discouraged the expensive "wild-catting" and deep sinking of the lower field. Since then there have not been added more than 3½ square miles of actual producing territory, making the total amount in the pebble-rock territory 54 square miles.

From the manner of "feeling one's way" with the drill in developing the lower country, the operator, in defining every five square miles of actual producing territory, condemned 60 to 100 square miles around him by his test-wells or autennæ, spread out in all directions. I believe this will be accepted as a fair estimate based on experience, and will dispose of at least 800 square miles.

Now as to the boundary lines of the entire oil section, ranging in length much over 400 miles, are all staked out by gas wells, dry holes, and failures, and as the area has been liberally estimated, we may safely draw around these boundaries a cordon of an average width of two miles, and that will dispose of at least 800 miles more.

There is not one particle of the territory south of Tideoute and west of the Allegheny river, as far down as Franklin, that has not either been exhausted or condemned for all purposes of quantity, by persistent and unmitigated "wild-catting." There is only left, on the west side of the Allegheny, all the way down below Franklin, a small belt or strip of land, what may be called uncertain land, on the west side of Butler County, and on the southwest corner of Venango County, not exceeding 180 square miles.

On the east side of the Allegheny, below Oil City, there is only a small area of not more than 40 square miles in the north part of Clarion County and vicinity, which may possibly be oil bearing. There is left on the east side of the Allegheny, north of Oil City, all that part of Forest County lying west of the great east boundary, still a wilderness, containing 350 square miles of uncertain pebble-rock territory, good for shallow wells (in spots, of from 100 to 500 feet deep). There is left also in the interstices, so to speak, of these larger areas, and scattered over them, a number of small uninvestigated producing areas which will, no doubt, be productive later to a small amount.

Any one who will give the subject candid consideration will not claim 500 square miles of what may be called uncertain territory in the pebble-rock division of the oil section; and the amount of actual oil territory, judging by the results of 20 years in the remaining 2,000 square miles, will not be more than 11 square miles.

The 1,200 square miles of the oil section north of Tideoute, which has been described as crevice territory, must be considered in an entirely different manner. The key to the exact location of the boundary line of the oil section in New York, on its north and west lines, may be found in the illustration given on previous page.

The crevice which furnishes the gas in the well at Fredonia, New York, on the lake shore, was found at a depth of 1,500 feet below the bottom of the oil wells near Olean, New York. (See section of oil country in Vol. J., 2d Geol. Survey of Penna.) That is why they find only gas in that section. The crevice reservoirs lie deeper and deeper as the waves of disturbance die out northward and westward, until they pass that point of the line of temperature at which oil can exist as a fluid. This line which I have described as the final north and west boundary, can be readily tested by any one who will take the record of the wells on the lake shore and the nearest producing wells, and measure off to the point between them that calls for a mean geological horizon of 2,000 feet from the mean gradient of the surface.

For the same reason no well in this section should be considered dry until it has been drilled at least 2,000 feet, and well shot with torpedoes. There are, no doubt, a number of wells which have been abandoned under the mistaken idea of the necessity of reaching a certain sand, and which might have been driven several hundred feet to a good production.

The proportionate area of actual producing territory in the crevice oil section will approach nearly to 40 or 50 per cent. It does not follow that the actual amount of oil obtained is necessarily much greater than in the pebble-rock section, for the wells are scattered more widely apart over large areas, instead of being huddled together over a small bed of sponge-rock in the lower region. Assuming that as much as 600 ou of 1,200 square miles of crevice-rock section will be found to be oily territory in the manner here described, Bradford and the vicinity of Olean have already consumed 230 square miles, well determined and already on their decline. This is a matter of commercial record. The time occupied in this exhaustion is the fastest on record, only a little over two years. Some 80 more square miles of new territory are also now in full operation, around Richburg and elsewhere.

With this simple outline of the oil field, and with the records of actual results, one can readily form an estimate of the amount of oil remaining. There is no necessity for republishing here the detailed tables of statistics of production of oil. The present situation is simply this:

If 54 square miles of the lower actual territory produced, in round numbers, 108,000,000 barrels of oil, then the eleven square miles left will give	22,000,000
If 230 square miles of crevice-rock territory produced 46,000,000 barrels, then the 370 square miles remaining will give	74,000,000
Total	96,000,000

It is only necessary to add that the present yearly output is over 25,000,000 barrels.

CONCLUSION.

There are many minor questions that are necessarily excluded in a concise presentation of this subject, such as the possibility of resuscitating old oil fields; of the imperfection of the surveys of Western Pennsylvania; of the enormous waste and destruction in the early oil developments; of the origin of the oil; of the effect of the denser gravity of the surface water on the oil in the rock, etc.

The thought which the writer desires to present plainly in this paper, which is the result of many years of close observation, is that the oil section has now reached a point of development when the amount of oil remaining can be measured with sufficient accuracy to predict definitely the life of the region. He does not wish to be considered a pessimist; he would be glad to know that he is wrong; but the possession of a check-book is not of itself an evidence of wealth. We have had a certain fixed quantity of oil placed to our credit in the Bank of Nature on which we have been drawing checks for 20 years; in 1875 we were checking out 6,000,000, and in 1882 we are checking out 25,000,000 annually. Some day the check will come back indorsed "No funds;" and we are approaching that day very fast.

* In Vol. J of the Second Geological Report of Pennsylvania, fuller details of these points can be found than the limits of this paper will permit.

MICROGRAPHIC ANALYSIS OF POTABLE WATERS.

PROF. L. MAGGI, in a paper read before the Royal Institute of Lombardy, discusses the methods employed in searching for *microbes* in water. Patience and skill of hand are rarely rewarded with success, unless some chemical reagent is employed. M. Certes uses *osmic acid*, which kills the minute beings, and when dead they fall to the bottom of the vessel in appreciable quantities, if enough liquid is used.

Certes describes the following experiment: He took 30 c. c. of distilled water in one test tube, and as much of the same water in another tube, which he stirred with a glass rod that had been dipped in water charged with infusoria. Each liquid had the same quantity of osmic acid put into it. In the first tube microscopic examination did not detect anything, in the second were found unharmed the organisms that had been transported in the minute quantity of water that had attached itself to the glass rod.

The toxic action and fixative power of osmic acid is general, for it is exercised not on bacteria alone, but also on the monads among flagellata; on amœbæ among rhizopods; on oxytrichina among the ciliata; on acaria, annelida, arachnids, and rotifers.

Finally, to avoid introducing other organisms than those which exist in the liquid treated with osmic acid, Certes recommends that the tubes, glass rods, object-glasses, and all the apparatus employed be washed in sulphuric acid, or heated in a flame. To facilitate the work for those who wish to control their experiments, he gives succinctly each step in the process that he adopted after numerous attempts.

For potable waters, filtered or not, but slightly charged with organic matter, Certes makes use of a 1½ per cent. solution of osmic acid. Less than 1 c. c. of this solution is sufficient for 30 or 40 c. c. of water. After this all the microscopic organisms, animal and vegetable, are rapidly killed and fixated in form. At the end of some minutes as much distilled water is added as the size of the tube will allow, in order to check the action of osmic acid, which, if left to act too long, blackens them too much.

In certain waters very rich in organisms the microscopic examination of the deposit can take place at the end of a few hours; but, for purer waters, it should be left twenty-four, or even forty-eight hours. In all cases it is only after a sufficient delay that the liquid is to be carefully poured off so as to keep only 1 or 2 c. c. of liquid containing the deposit. At this moment the operation is ended.

This new process seemed to me convenient for examining diverse potable waters. In the first place, I applied it to the waters of Lake Majeur, taken at a depth of sixty-five meters below the surface, between Angera and Arona. This was early in May, when I took charge of the analyses of these waters. Engineer Canevari, of Rome, had proposed to supply Milan with water from this lake at that depth, and it had been made the subject of a report of two Milanese engineers. Profs. Padulli, Kœrner, and Carnelutti have been occupied with the chemico-physical analysis of this water, and found it suitable for industrial and domestic purposes.

On my tour of examination I examined it with the microscope with reagents, both there and in my own laboratory in Pavie, not only immediately, but also at the end of one, two, and even three months, having kept it in bottles hermetically sealed. I did not see any microbes. Nevertheless, after the close of my researches, I wanted to analyze it with osmic acid, by Certes's process. After forty-eight hours' rest I obtained, at the bottom of the vessel, a slight deposit, which was magnified eight hundred diameters, and examined by the microscope. Forms similar to those of bacteria were seen, and particularly of desmidieæ; some of these approached in form the *Bacillus ulna* of Cohn, or *vibrio bacillus* of Dujardin; while others resembled the *vibrio serpens* of Warming, but motionless, since they had been killed by the acid, their normal shapes preserved and precipitated to the bottom of the vessel.

Reflecting that osmic acid is but one of the means of hardening protoplasm, and that the aforementioned organisms ought to be visible after being submitted to the action of the reagents, I thought to repeat the experiment with other methods for hardening which are at the disposal of the practical microscopist. With this aim, I chose the chloride of palladium in a solution of 1 to 800, and treated the water to be analyzed with it in the same proportions as with the osmic acid—that is to say, 1 c. c. of chloride of palladium solution to 40 c. c. of water.

In a few minutes a sediment was deposited of a more or less intensely yellow color, or a fine orange. At the moment of introducing the chloride of palladium the water looks turbid and yellowish; but when all the suspended matter is precipitated, it becomes colorless and limpid again. A microscopic examination (with 800 diameters) revealed bacterian forms resembling those seen by the aid of osmic acid, and many little masses of irregular shape and granular structure, colored golden yellow, and capable of taking a red color when touched with a solution of magenta. This result makes me think they were of a protoplasmic nature, and furthermore, that chloride of palladium would be a convenient reagent for fixating the organic substances found in potable waters. If it be acknowledged, in fact, that chloride of palladium put in water only fixes organic matters, it will be an excellent reagent for them, since it will reveal the quantity to the naked eye. Be that as it may, chloride of palladium, like osmic acid, has the property of hardening micro-organisms, whereby they are made opaque and visible to the microscope. The hardening which facilitates the study of animal tissues in histology has equal value in protistology for the study of inferior organisms.

This application of the hardening process has some importance, because with the coloring reagents already employed for the study of the protides, they constitute a general (technical) microscopic system for all organic forms. Nothing more logical is given than that the protides are the elements (factors) of the tissues of the metazoa, and that consequently they cannot differ very much from these in their action toward the same reagent. It is only necessary to modify the proportion of the reagent in consequence of the differentiations undergone by the protides which constitute the tissues of higher animals.

Nevertheless, I cannot silently pass by the results of my examination of the waters of Lake Majeur in treating them with picrocarminic acid, hematoxyline, methyl violet, carmine, magenta, Lyons blue (aniline blue soluble in alcohol), fuchsine, cyanine, cosine, carmine lake, and carmine borate. In whatever proportions these coloring solutions were used, I have always obtained the results already described under osmic acid and chloride of palladium.

Leaving the details of this long research for another occasion, I will only say that my best results were obtained with hematoxyline, methyl violet, magenta, and Lyons blue, because they rendered visible the same immovable micro-organisms and the same protoplasmic masses as had been seen before with osmic acid and chloride of palladium. The coloration of the protoplasmic masses has always been the same as that of the reagent; but what is singular, the micro-organisms remained colorless. For this reason, and because in all my experiments I found the same organisms, I ought to reject the doubts that they could have existed previously in the reagent employed.

Each time I repeated my experiment with new reagents, and those that were soluble in water I dissolved in water that had been distilled over permanganate of potash. They led to the same results as the previous ones. In the last place I repeated the same experiments, using the water to be analyzed instead of distilled water for dissolving the reagent so as to exclude any effect of that liquid. Again I found the same colorless micro-organisms and the same colored masses of protoplasm.

The question still remains, How are we to know whether these micro-organisms are harmless or not?

To decide this I did think to have recourse to the examination of potable waters from springs which experience had proved to be best, and of rain-waters considered equally so. Among the former, I chose those of Valcuvia, which come from the Jura formation, and among them those which usage had proven were of good quality. Notwithstanding the results of physico-chemical analysis, the empirical criterion of the potability of water, based on this fact, that it is a question of its source, also proved fallacious.

I wanted to test rain-water, which is recognized and acknowledged by long usage to be fit to drink, and I collected some on the first of last September. Not to take too much space with the details of these researches, I will merely say that in all the waters examined with the microscope, under a power of 800 diameters, without reagents, I did not find a single microbe of any form, but that the microbes seen after coloring and hardening were identical in form with those from Lake Majeur. I will add they were relatively more numerous than in the spring-water. Yet it seems to me that the harmlessness of these micro-organisms, rendered visible by the process just indicated, can be asserted with still more reason, because no one has known of any special malady occurring at Valcuvia.

Without the use of reagents these beings are invisible with the microscope; wherefore, I propose the name of *afaneri* (invisible), to distinguish them from the bacteria or microbes, which are visible in the microscope without reagents, and among which are those of infectious diseases. These *afaneri* become visible by the process of hardening. There is ground for thinking that they are not only very delicate, but that there is a large amount of water in their constitution, which explains the fact that their transparency is equal to that of the liquid in which they live; and hence their invisibility. These beings are motionless when seen in the microscope, but their immobility is certainly due to the process employed to render them visible—a process that kills them. If dead, how could they remain uncolored in the coloring solutions? Their properties ought to be different from those of bacteria, visible in the microscope without any reagents, the *faneri* (visibles), which are colored particularly by methyl violet, magenta, etc. Researches made in regard to this* show that the *afaneri* of the same water are always colored with methyl violet after they have been dried. But this is not a biological property; it is a cadaveric property, or rather a property manifested as the result of cadaveric alteration.

Perhaps they furnish carbonic acid to the water in which they live; but here hypotheses begin, upon which I do not wish to enter, desiring for the present to restrict myself to observed facts.

These facts can be verified by persons possessing good means of observation, such as have the good fortune to have at their disposal the new optical instruments (Abbé-Zeiss), and they can serve to decide whether a water is potable or not, inasmuch as the presence of *afaneri* can be considered as charcteristic of the healthfulness of water.

Although the facts that I have observed will not, for the present, be of any other value, it is at least permissible to draw this conclusion, that technical microscopy can be successfully applied to the examination of potable waters.

R. S.

* The coloring experiments have been made by leaving the organisms in the coloring solution for a month, when they became visible. I have begun other experiments after drying, and will communicate the results at another time.

THE MANUFACTURE OF THE COAL-TAR DYES.

PREPARATION OF NITROTOLUOLS AND TOLUIDINS.

Toluol is the second compound in the benzol series, boils at 110° to 111°, and forms, on treating with nitric acid, nitro compounds similar to that obtained from benzol. There are, however, two varieties, and these produce on reduction, by the same process as that described for anilin, two toluidins.

Nitrotoluols.—The manufacture of these compounds is effected in the apparatus described for nitrobenzol, and is a process requiring great care and attention, since the temperature at which the combustion of the acid and toluol is effected determines the relative quantities of solid and liquid nitrotoluols, and consequently the isomeric toluidins. When toluol is treated with nitric acid both modifications of nitrotoluol are always produced. But to obtain a larger proportion of the solid variety, M. Charles Girard recommends the use of fuming nitric acid, as free as possible from nitrous acid, and the combination must be effected at a temperature as low as possible. To produce the liquid variety, on the other hand, a mixture of nitric and sulphuric acid similar to that already described for the nitrification of benzol is required, and the temperature allowed to rise until the mixture in the apparatus is nicely warmed. The decomposition which takes place during the above process is represented by the following formula :

$$C_7H_8 + HNO_3 = C_7H_7NO_2 + H_2O$$

Toluol and nitric acid produce nitrotoluol and water.

The Toluidins, corresponding to the two nitrotoluols known as solid and pseudo-toluidin, are produced by the reduction of the nitrotoluols with iron and hydrochloric acid in the same stills as those used for the preparation of anilin, and also in a similar manner to that described under anilin. The following formula shows the decomposition which takes place on reducing nitrotoluol:

$$C_7H_7NO_2 + H_2O + Fe_3 = C_7H_9N + Fe_3O_3$$

Nitrotoluol and water and iron produce toluidin and ferric oxide.

When the mixed toluidins have been removed from the residue in the stills it is necessary to separate the two modifications, and to this end De Laire and Vogt give the following process: There is added sulphuric acid sufficient to neutralize the solid variety, after which the whole is boiled and the pseudo-toluidin separated from the sulphate of toluidin by distillation with steam, the pseudo-toluidin being carried over mechanically suspended in the vapors. The seven or eight per cent. of the solid always accompanying the pseudo-toludin is saturated with sulphuric acid, and the mixture again rectified to obtain a pure product. To liberate the base combined with the sulphuric acid it is, of course, necessary to use an alkali, lime being the least expensive kind.

MAGENTA, OR ROSANILIN HYDROCHLORATE.

Rosanilin Acetate and Rosanilin, etc.—There are two methods by which this color is produced, the one being by oxidizing a mixture of anilin and toluidin, known generally as anilin 30 per cent. and 40 per cent., by means of arsenic acid. This is the process usually adopted in England. The other a process first proposed by M. Coupier, and generally employed on the Continent, in certain parts of which the use of arsenic is prohibited by law. It must be borne in mind that, although arsenic is used in this country for the manufacture of this beautiful dye, that poisonous compound is thoroughly removed before the color is sent into the market.

Arsenic Acid is produced from the lower oxide of arsenic, known as white arsenic (arsenious acid), by the addition of oxygen. This is effected by means of nitric acid, and should be properly carried out in an economical manner by forming nitrate of soda to be used in the manufacture of azo colors, or reoxidizing the nitrous acid into nitric acid. To effect this a quantity of nitric acid is poured into a large stone cistern and the white arsenic gradually added The arsenious acid is oxidized into arsenic acid, and nitrous acid is liberated. This is conducted into a tower, and oxidized by the oxygen of the atmosphere into nitric acid; or better, this gas, after washing by water, is absorbed in a soda solution, to produce nitrate of soda. This is the better plan, when this substance is required to produce the azo colors. Generally, when the manufacture of nitrate is required, the whole of the arsenic to be oxidized at one time is thrown into the cistern, and the nitric acid gently run on to it. As we have already said, this is the more economical plan. The tank where the operation is carried on is covered with a stone lid, and the siphon pipe used to run the nitric acid from the bottles is admitted through a small hole in the lid, and the nitrous gas evolved during the decomposition is drawn through several of Wolfe's bottles containing water to dissolve the nitric acid, which always contaminates the nitrous gas, and then through a solution of soda by a properly constructed air pump. To 400 pounds of white arsenic there is consumed about 300 pounds of nitric acid. In practice an excess of white arsenic is always used, to insure the absence of nitric acid, and the thorough completion of the process is obtained by boiling the mass equally by free steam.

Magenta.—We shall first discuss the plan usually adopted in this country for the manufacture of this color, *i. e*, by oxidation of 30 per cent. or 40 cent. anilin, by means of arsenic acid. To effect this there is introduced into a properly constructed still 100 parts of the anilin oil and 158 parts of arsenic acid solution, having a specific gravity of 1·84, equal to 66° B., or 168° T. This mixture is then heated, the heat being at first gently applied, in order that boiling over may be avoided, until a temperature of about 200° C. is indicated by the thermometer, and maintained at that degree until the formation of the color is complete. The cast-iron still, commonly called the melt pot, in which the operation is performed, is set on a fireplace constructed with an arch, so that it is protected from the direct heat of the fire, which is liable to burn the melt. A still is a cast-iron boiler, with a round bottom, having a neck through which the melt can be run out when finished. They are, in fact, similar in shape to ordinary domestic boilers used for laundry purposes, but much larger and of greater thickness. The flange round the top is wider, so that a lid may be fastened on with nuts and screws. Through the center of the lid a shaft passes, and is made steam-tight by means of a stuffing-box packed with asbestos. At the lower end of this shaft, and at an angle of about 45°, are agitators of such a shape that they fit within a quarter of an inch of the still bottom. This shaft stands on a footstep at the center of the pan. There is a manhole, where the charge can be introduced, and at some convenient point there is a small hole, in which a pipe is screwed. The bottom end is closed, and dips into the melt. A little oil or paraffin wax can be put in this, and a thermometer. A large pipe is also attached to the lid (see Fig. 1), and connected with a condensing coil. To find when the formation of the color is finished a small sample is drawn off through a small tap, situated at some convenient point near the bottom. This on cooling should be brittle, and exhibit a fine bronzy appearance. The finish is also indicated by the amount of anilin and water stilled off, condensed in the coil, and collected in proper receivers, which amounts together to about one-half by volume of the anilin put into the still. Having ascertained that the color is properly finished, the outlet, which is stopped during the process with a plug or treacle trap, is opened, and the hot melt run into sheet iron trays, or sometimes a shallow pit made in the floor, with the bottom flagged. Previous to receiving the melt this pit is sprinkled with whiting, to facilitate its removal. After it has grown cold the mass is broken up for extracting the color. The extraction may be accomplished by two methods. In one soda crystals are used, and in the other whiting (carbonate of lime). In the former case the broken melt or crude color is thrown into an iron pan, along with sufficient soda crystals to neutralize the arsenic, and a quantity of water. This pan is either jacketed or heated with a good coil laid on the bottom. The steam is then turned on, and the whole thoroughly boiled for hours to insure the removal of the arsenic. By this means there is formed arsenite and arseniate of soda, while the color remains in an insoluble state, the arsenical liquor, drained from the color and concentrated by evaporation until a sample, on cooling, solidifies, has a pinkish color, and is either sold in this state or first roasted to remove the color. This salt is largely employed in certain calico-printing operations. The insoluble color is now put into an extractor, a large cast iron pan, fitted with agitators, and having a steam pipe attached, by which the contents may be boiled with free steam, along with a large quantity of water; and to form the color into a soluble salt a little arsenic acid solution, such as is put into the melt-pan, is added. After the contents of this extractor have been well boiled for two hours, the steam is stopped and the liquor allowed to rest for some time, to allow the insoluble matters to subside. The solution of color is then run off and filtered through fine brown calico, so that any insoluble matter which may still remain suspended is arrested. The clear solution is collected in large vats, and the color precipitated by adding a large excess of salt. This precipitate consists of rosanilin hydrochlorate, and is formed by a double decomposition between the common salt (sodium chloride) and the arseniate of rosanilin, the arsenic and chlorine exchanging positions. The residue remaining in the extractor is repeatedly boiled, to remove all the soluble color, and the liquors treated with salt in the same way as the first. When the soluble portions have been removed the insoluble part is kept for further treatment, to be presently

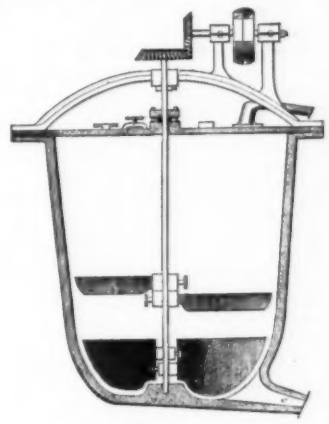


FIG. 1.

described, since it contains other coloring matters to be subsequently turned to account. To extract the rosanilin salt, by using whiting or chalk, the broken melt is thrown into the extracting apparatus, steam turned in, and boiling commenced. The whiting is added by small portions at a time, until the arsenic acids are neutralized. This point is easily discovered by the ceasing of the frothing, which always takes place while free acids exist in the solution. After a thorough boiling the liquor is allowed to rest, and is then filtered into the salting vats and treated as described above. Sometimes the extraction is carried on in closed vessels, under a pressure of about 60 pounds or 80 pounds per square inch, and at a temperature something like 140°. The advantage gained by this is that a batch of color can be exhausted with less water than if the open pan is used. The time occupied is also less. It is economical with such an apparatus to have the outlet pipe of the boiler attached to a filter press, and force the color through by the pressure used for the extraction. By this means the liquor is delivered into the salting vats, nearly boiling hot. The insoluble matters in the press can be readily and quickly washed with boiling water, and the residue made much drier than when the ordinary filter is employed. We had almost forgotten to point out that the closed extractor is equally suitable to the treatment of the magenta (crude) base formed when the melt is treated with soda to remove the arsenic, and would be very efficient if used for this purpose.—*Textile Manufacturer.*

DETERMINATION OF SUGAR WITH FEHLING'S LIQUID.

The author proposes the following method for ascertaining if the reduction of the copper is complete: There are placed upon each other two fragments of white filter paper. Upon the upper fragment there is placed, with the stirring rod, a drop of the boiling mixture of Fehling's liquid and of the saccharine solution, holding cuprous oxide in suspension. The paper acts as a filter, and only the copper in solution, and consequently not reduced, arrives on the lower paper. Upon the drop thus filtered there is laid a drop of a dilute solution of potassium ferrocyanide, and the paper is dried over a spirit-lamp. If there is an appreciable quantity of copper, the spot, on drying is surrounded with a rose-colored halo. If there is a mere trace, the characteristic rose tint appears on moistening the spot with a drop of acetic acid. If the copper is entirely reduced, heat and the application of acetic acid produce a blue spot, due to the decomposition of the ferrocyanide.—*E. Boiret.*

NERVE VIBRATION AS A THERAPEUTIC AGENT.

By J. MORTIMER-GRANVILLE, M.D.

ENLARGED experience in nerve vibration as a means or method of treating disease has confirmed my belief in its value, and I have no longer any hesitation in recommending its adoption by the profession. I do this with a full sense of the responsibility which necessarily attaches to the propounder of any strange doctrine in medicine, such as that which the theory of nerve vibration, undoubtedly, presupposes and implies; and in an especial sense to the introducer of a new therapeutic agent. The responsibility of strongly urging a recourse to nerve vibration, I am now fully prepared to accept. I commenced the investigation of nervous phenomena, first in connection with the various forms and causes of "pain," more than twenty years ago, and this method, which has been mentioned rather than recommended by me on several occasions during the last few years, is the outcome of a long and careful series of experiments. I have now employed it in a very considerable number of cases, differing widely in their nature and characteristics, and although I have had many failures—mainly, as I believe, from errors in diagnosis and mismanagement in the application of the treatment—the net result has been such as to place beyond reasonable question the fact that in precisely applied mechanical vibration of nerves and nerve centers, we have a means of eliciting function and stimulating nutrition which surpasses for directness and rapidity of action any other system or method extant. If this should seem to be an over-statement of the facts, it must be borne in mind that it is made in a medical journal, and with the knowledge that the profession will soon be able to verify or disprove the accuracy of my assertions.

I do not propose to publish my cases immediately, because sufficient time has not yet elapsed since the occurrence of what I conceive to have been "cures," to show that they merited that description. At the same time, although as I have said, there are many obvious failures in my record of cases treated in this manner, the benefits which seem to have accrued from its adoption are so marked that I do not feel justified in longer delaying the step by which I place the means of forming a judgment on my method in the hands of the profession. Mr. Frederic Weiss, of the firm of Messrs. Weiss & Sons, has greatly aided me in producing, and will shortly be able to supply to members of the profession—I hope *exclusively*—a very satisfactory percuteur worked by electricity. I must acknowledge my indebtedness to Dr. George Balfour, of Edinburgh, for the recommendation to use electricity as a motive power. My deeply regretted friend, the late Mr. Donald Napier, advised me to employ this agent some five years ago, but I was then reluctant to do so, lest it might be supposed that my process was in some way a modification of the use of electricity. It should, therefore, be understood that no current passes through the hammer of my instrument. The patient is not in the circuit. This force is, however, more convenient for sustained use than that obtained from the clock spring in my mechanical percuteur. Messrs. Weiss & Sons have also a clockwork apparatus which has been made under my supervision, and which renders practicable what the French instruments have not, with a few exceptions, hitherto enabled me to accomplish. I will now briefly state the principles of the treatment, and leave it in the hands of the profession to give it a trial.

In the treatment of neuralgia, I believe percussion acts simply by interrupting a morbid series of vibrations, and substituting for it another series which is not morbid. Its success is by no means certain; but it deserves a trial, and particularly in cases which would otherwise be treated by nerve stretching. When a nerve is stretched, it is for a time, at least, prevented from vibrating. When it is mechanically vibrated by percussion, it is compelled to fall into a new rhythm by the physical law of harmonies and discords. There are several modes of procedure. The percuteur may be applied over the seat of pain with varying force and speed until alleviation of the trouble is produced; or the percussion may be made higher up in the trunk of the nerve, over the center, or at a more distant point in the periphery. If these methods fail, an attempt may be made to act upon the real, or supposed, seat of the pain indirectly through some other set of nerves. If success should not attend either of these modes of procedure, the irritation which causes the pain will probably be found to be reflected from some remote seat of disturbance, as in the case of pains in the heels from piles; and this seat of the *exciting* cause may generally be discovered by the physiological anatomist who will take the trouble to run over and exhaust the series of probabilities. The plan I suggest is, of course, far more exacting than the time honored expedient of giving an anodyne; but *relieving* and *curing* pain are two totally different processes, and it is only with the latter I have any concern.

For the rousing of torpid nerve centers and eliciting function from the several organs of the body, I believe nerve vibration to be of the highest possible value. The recognized topography of the centers may serve as a rough guide for the application of the percuteur; but as it is essential that the particular nerve energizing the organ should be acted upon, and, as precisely as possible that *only*, the operator will need to tax his knowledge of the nervous system in every case specifically. In a large proportion of instances the organ will have to be approached by a circuitous path, which can only be discovered by experiment in the individual case under treatment; and the search for a way of reaching it must be made with a practical knowledge of the whole of its nervous connections. It should never be forgotten that the therapeutic agent is mechanical *nerve* vibration; and unless the nerve we want to stimulate is actually thrown into vibration it will not be excited to action. Every organ of the body, from the liver to the testicle, may, in the absence of disabling organic disease, be made to perform its proper function by exciting the nerve, which supplies it with energy, by mechanical vibration. In this way I have seen the liver unloaded, and what seemed to be inveterate torpidity of the intestines remedied, in a few successive vibrations. I have now under treatment the case of a child, who was six weeks ago to all appearance an idiot; but who has already developed so much cerebral activity and growing intelligence under the influence of specific center and nerve vibration, that I entertain the strongest hope of his ultimate awakening, and a fair approach to the normal state. A surprising amount of success has attended percussion in cases of obstinate, and what was supposed to be irremediable, deafness. In a certain class of cases the hearing seems to have been recovered by arousing the auditory center. In another class of instances of benefit derived, I believe this has been due to the re establishing of the mobility of the ossiculæ by mechanical vibration at a very high speed, the tonicity of the muscular fibers attached having been at the same time restored.

In neurosthenia, neurasthenia, and even commencing sclerosis of the spinal cord, with loss of tendon reflex, the most remarkable effects are produced by applying the percuteur over the spirous processes of the appropriate vertebræ. I am afraid at present to publish some of the results recently gained. In a few cases I have wholly failed to do good, but in others—not a few—the locomotor ataxy has been removed or sensibly ameliorated, and the general improvement may be fairly described as astonishing. It is often necessary in this class of cases to combine proximate central percussion with lighter percussion at the remote periphery, especially when there is much trouble from lightning pains, or that creeping paralysis which so often first shows itself in the tibialis anticus.* In cases of exaggerated reflex irritability—a very common phenomenon, which is too generally overlooked—I find the best plan of procedure to be by percussion over the seat of the irritability until that is removed, which generally happens after a very few applications of the percuteur. In a majority of my cases the subjugation of this irritable state has been almost immediately followed by motor improvement.

One significant effect of nerve vibration is observable in the influence it exerts on the vaso-motor system, as indicated by the pulse tracings.

I do not wish to lay greater stress on the clinical value of the records taken by the sphygmograph in consulting practice than may be justly due. For myself I would not readily dispense with the aid afforded by that instrument in judging of the actual state of any patient. I am careful to apply it under, as nearly as possible, the same conditions of pressure and adjustment on each occasion, and I regard as important only the angle formed by the up-stroke and the decline, together with the *relative* proportional amplitude of the waves on the descending line as compared with the height of the up-stroke, whatever that may be. I think, however much we may differ as to the significance of the tracings observed, it will be conceded that the effect of the treatment upon the vaso-motor center must in each instance have been marked. To this influence I attribute, in a conspicuous degree, the change effected in the general health as well as the amelioration of the particular symptoms.

In ordinary paralyses, which depend upon or are accompanied by deterioration of the muscles, I think nerve-vibration by percussion is inferior in value to electricity. In short, I do not think it has any appreciable effect except on the nerves themselves. It certainly improves the nutrition of nervous tissue, and this indirectly promotes the nutrition of muscles, but the process is circuitous and slow. Faradaism is a preferable remedy. Nerve vibration is not the rival of electricity. The two agents act in totally different manners. Vibration simply excites a nerve center to such activity as it may have strength or power to perform. It does not impart any new energy or introduce any new force to the system. Electricity infuses an extraneous force into the organism, but with this drawback, that it is impossible to insure its acting *only* on the nerve it is desired to stimulate, and solely in such a way as to render any act of that nerve *its own*, and therefore normal. Vibration cannot possibly act in any other way than through the nerve or upon the center, and, in a strict sense, nervously. One curious effect of percussion may be more interesting to the physiologist than to the practitioner, but I will place it on record. Playing over the center from which the nerves supplying a particular set of muscles arise is apt to produce a feeling of fatigue or stiffness which may seem to be located in the leg or arm, although the extremity itself is not touched. This will help to explain how what is called nightmare may produce cramp, and how the activity of certain automatic centers in a wearying dream of action may give rise to a sense of fatigue on waking.

These few hints will serve to point the practitioner to a method of procedure in making trial of the remedy, but all I know of the method is at the disposal of any member of the profession who may desire to be more fully or precisely informed. I will only say, in conclusion, that I am very hopeful that nerve-vibration will enable us to cure maladies which have hitherto been beyond remedy; and that in a certain class of cases—namely, those which require the direct stimulation of nerve-centers for their recovery—this agent will greatly help, perhaps supersede, the use of drugs.—*Lancet.*

* I believe Dr. Hughlings-Jackson has somewhere noted this clinical fact, but, at the moment, I do not remember in what connection or where.

CONSUMPTION A PARASITIC DISEASE.

ON the 24th of March, 1882, an address was delivered by Dr. Koch, before the Physiological Society of Berlin, the essential facts of which are as follows. Prof. Tyndall has confirmed these experiments, and they may be considered reliable:

Dr. Koch made himself known by his experiments on the contagium of splenic fever. He subjected the diseased organs of a great number of men and animals to microscopic examination, and found in all cases the tubercles infested with a minute, rod-shaped parasite, which, by means of a special dye, he separated from surrounding tissue. This minute parasite or organism was always found in the center of the tubercle cell, the minute organism which had created it. Transferring directly, by inoculation, the parasite or bacillus from diseased animals to healthy ones, he in every instance reproduced the disease. To meet the objection that it was not the parasite itself but the virus in which it was embedded in the diseased organ, he cultivated his bacilli artificially for a long period of time and through many generations. With a speck of matter, for example, from a tuberculous human lung, he infected a substance prepared after much trial by himself with the view of affording nutriment to the parasite, permitting it to grow and multiply. From this new generation he took a minute sample and infected therewith fresh nutritive matter, thus producing another brood. Generation after generation of bacilli were developed in this way without the intervention of disease. The purified bacilli were introduced into the circulation of healthy animals of various kinds. In every case, inoculation was followed by the reproduction and spread of the parasite and the generation of the original disease.

Of six guinea pigs, all in good health, four were inoculated with bacilli derived from a tuberculous human lung. Two of the six were not infected. In every one of the infected cases the guinea pig sickened and lost flesh. After thirty-two days one of them died, and after thirty-five days the remaining five were killed and examined. In the guinea pig that died and the three remaining infected ones strongly pronounced tubercular disease had set in; spleen, liver, and lungs were found filled with tubercles, while in the uninfected animals no trace of the disease was found. A large number of experiments are recorded in the Doctor's essay, from which the weightiest practical conclusions may be drawn, says Prof. Tyndall. Koch points to the grave danger of inhaling air in which particles of the dried sputa of consumptive patients mingles with the dust of other kinds. The *Medical News* states the evidence seems conclusive; it only remains to develop from the cultivated parasite tuberculosis in man to complete the cycle of evidence and to establish Koch's discovery among the great facts of medical science.

Koch is not the only one who has propagated tuberculosis by inoculation, but is the first to isolate the bacillus. Villemin, Colin, and Lebert declare that they have propagated it in animals by inoculation. A report by a commission of the French Academy on the former's experiments, says that "all inflammatory products have, when inoculated, similar effects to those of tubercle."

Dr. Marcet, of London, confirms, by his own experiments upon animals, the inoculation of tubercle from the sputa of patients.

If the seriousness of a malady be measured by the number of its victims, this is surely it.

One-seventh of the deaths of the human race are due to tubercular diseases. Taking it for granted that the pathology of consumption is now understood, have we an antidote for the tubercle bacillus? Many intelligent physicians have advocated the theory of the cryptogamic or parasitic origin of diseases. The late Dr. Thompson, of Tennessee, wrote a "Practice of Medicine," in which this theory was strongly urged, and his practice was in accordance with this idea. He thought that oil of sassafras, taken in the system, was an antidote to parasitic life. It is supposed that oil of turpentine acts thus beneficially on the diseased glands of Peyer in typhoid fever.

Perhaps the preparations of petroleum will be found the best antidote for the tubercule-bacillus, as no living insect can exist in it. It has proven a success in destroying the insect that ravaged the vines of the vineyards of France.

Dr. M. M. Griffith, of Bradford, Pa., has reported the most remarkable success with petroleum in consumption with what he terms petroleum mass, a condensation of petroleum; he uses it in pill form. The mass is combined with sulphate of cinchonidia and Dover's powders—two grains of the former to one each of the latter. His idea was similar to Dr. Koch's, that the disease was caused by a microscopic parasite. His percentage of cures were remarkable.

The use of various antizymotic solutions, as sprays, find many advocates, such as carbolic acid, the sulphites, etc. They act only locally, as the fine particles thrown or inhaled in the lungs are carried to the affected parts.

I am fully convinced that the day is not far distant when we will find a cure for this scourge of the human race.

WM. HUGHES, M.D.

Salamanca, N. Y., May 24, 1882.

SPREAD OF SCALE-INSECTS.

I WATCHED to-day a colony of *Hyperaspidius coccidicorus* (Ashmead), which has for two months or more been increasing on the trunk of a tall seedling orange tree. The main trunk of the tree is covered densely with Chaff scale, and upon it the larvæ and imagos of the beetle are feeding. The greater number are now in imago. I found but one pupa, although larvæ are still abundant. The beetles, both larva and imago, feed upon the Coccids in all their stages. They never bite through or tear off the scale, but seem to push their heads under, between the bark and the scale. Larvæ of the scale-insect are quite abundant on the trunk, and these are sucked by the Coccinellid. Although this is not properly a breeding time of the scale, there are considerable numbers of scale larvæ wandering about, and I noticed again and again that they frequently mount upon the bodies of the Coccinellids while the latter are feeding, and without attracting the attention of the beetle. It even seems to me that they are attracted by the smooth and shining surface of the Hyperaspidius' elytra, as I sometimes saw three or four of the scale larvæ together upon the back of a single individual of this extremely small beetle. As several large Coccinellids, *Chilocorus bivulnerus, et al.*, are extremely common in all our groves, and all feed more or less upon Coccids, it does not seem surprising that the scale should spread from tree to tree. Another method of transportation has recently occurred to me. The shrike or butcher bird is very fond of selecting orange thorns as places to store insects. The bird is extremely common, and of course preferably selects orange trees that have long straggling branches, in fact precisely those that are most thickly infested with Long scale. I know of one grove, much infested with scale, and where at any time may be collected a double handful of dead or living insects (Orthoptera, and common beetles like Phanæus) from the orange thorns upon which they have been impaled. The thorns on infected branches are always thickly coated with Long scale, and in impaling a hard shelled insect like Phanæus many scales are torn off, and both scales and their eggs adhere to the insect. The shrike sometimes transfers the insects it has impaled upon one tree to a thorn upon another tree, or after making a meal of its prey which it takes off of a thorn, the bird flies off and wipes its bill on the next tree. In this way, as well as upon its feet the bird must spread scales from tree to tree.—*H. G. Hubbard, Fla., in Amer. Naturalist.*

THE MALAY ADJUTANT.

THE family of the storks contains a series of strange but very interesting birds, several of which are, no doubt, very familiar to the visitors to the gardens of the Zoological Society of London. Of these, the Malay Adjutant—*Leptoptilus javanicus* (Horsf.)—is, from its odd manners, not the least in interest. In a very pleasantly written series of notes made on the birds of the Straits Settlements and of the Western States of the Malay Peninsula by Lieutenant Kelham, and published in the current number of *The Ibis*, we find the following graphic account of a pair of these birds which had been purchased by a detachment of the Seventy-fourth Highlanders, who, in June, 1877, were stationed at Penang. The birds stood about three feet in height. They were never kept in confinement, and from the very first were allowed to roam over a large, open expanse of ground. They never seemed inclined to stray far, and very seldom ever attempted to fly. When they did so it was rather a failure, and consisted of a succession of bounds for about fifty yards, after which they appeared to be quite exhausted. They gave one quite the idea that their surroundings had but little attraction for them, as they would spend more than half the day standing motionless opposite each other, bill to bill; and with both their wings outspread, forming a most ludicrous picture. Sometimes, after standing like this for an hour or more, one or the other would occasionally raise and stretch out one of its legs as if it were stiff, but otherwise scarcely stirring a muscle. They were never heard to utter a sound. They were coarse feeders, and neither quality nor quantity seemed to trouble them much; one of them on an occasion gulped down one by one as fast as they could be thrown to it thirty-two small fishes, each about six inches in length, and evidently was ready for more. After they had been with the regiment about a month, one of them began to look downcast. One morning it remained basking in the sun for several hours, with outspread wings. Later in the day it lay down on the grass with its eyes closed, and evidently very sick, and by it stood its brother, apparently quite unconcerned. Like this they remained until late in the afternoon, when the healthy bird was seen to put his head on one side, and, looking curiously at his sick comrade, proceeded to stir him up with his beak, without making him move; and on going to look he was found to be dead. A *post mortem* examination was immediately held, and in the poor bird's stomach were found the legs and claws of a large fowl, quite undigested, which were the apparent cause of the intense inflammation. While the investigation was going on, the surviving bird evidently regarded it with much interest, and as great lumps of muscle were stripped off his comrade's bones he gobbled them up. Having thus got a good meal, he at length stalked demurely away, satisfied with his afternoon's performance, and apparently thinking what a pity it was that he had not a brother dying every day.

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